Data Models for Virtual Distribution of Musical Scores

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Abstract

With the rise of portal sites for image-file download of musical scores, the electronic distribution of musical scores, an activity in progress of 15 years, has attracted increased attention. We describe several data models for score distribution and emphasize the one used in the MuseData archive of musical data (1984–). This archive (containing substantial quantities of the music of Bach, Handel, Haydn, Mozart, Beethoven, Corelli, and Vivaldi) employs a "solar" model of supersets of musical data. From these files for score printing, sound generation, and logical information for musical analysis can be generated. The design, efficiencies, and shortcomings of this "write-once, convert-many" system are compared with models emphasizing generic musical-data interchange, and models in which music must be re-encoded for each new application. Finally these considerations are examined in light of social practices and economic models traditionally associated with the print publication of music in Europe and the U.S.

1. Introduction

Electronic distribution can take many other forms; prior to the existence of the Web there was some distribution of machine-readable files via available storage media. The storage media do not disappear in Web distribution; they simply remain under the control of the distributor. The chief motivation for commercial Web distribution of musical scores seems to be to implement rights-management schemes that will enable existing publishers to continue to do business pretty much the way they did before the Web existed. That is, they want to control **what** is published and **how** it is distributed.

2. Traditional Values and Modern Technology

In the case of standard repertories used in conservatories and concert halls the **what** of publication has been managed in highly authoritarian ways for the past two centuries. Numerous boards, commissions, agencies, and other corporate bodies have been carefully appointed to assure "high standards" of content and presentation. The first challenge posed by the Web is that it is completely indifferent to quality.

Paper publishing has been a valuable asset to the control of musical content as well as to presentation quality. Music distributed on paper is in a fixed form; the accretions of learning and interpretation, once committed to paper, may as well be cast in concrete. The **how** of paper publication of standard repertories in "monumental" editions (e.g., in series of *Tutte le opere* in Italy or official *Ausgaben* under the editorial authority of a composer *Gesellschaft* in Germany) has by default also protected a social structure and a set of relationship between the revered composer, the society, the publisher, and at many junctures a nation and its pride. At the same time, it has protected subsidiary fine arts–e.g. the visual artistry of musical typesetting (now reduced to a cottage industry in Eastern Europe and a few third-world countries). From roughly 1750 onward music publishing successively sought the sponsorship of the wealthy, the approval of monarchs (more recently the financial assistance of governments), the interpretations of *virtuosi*, and (in our lifetimes) the potential to spin-off from what copyright law calls "derivative works"–text translations and recordings.

To the extent that the Web redefines methods of distribution through technological enablement, it also coincidentally redefines these social structures. It sometimes obliterates them. Music distributed electronically will not inherently enhance the image of the rich and the powerful, will not glorify the state, will not enshrine the musical interpretations of star performers or encapsulate the learning of musical scholars. Notation-software developers have not been slow to realize this. While music publishers fret over how to deal with new technology and its implications, notation developers, aided by the Web as a medium of delivery, have been rapidly colonizing the landscape with the trappings of e-commerce—proprietary viewers for image files (provided that the files are created with the provider's software), schemes for deposit of new compositions at portal sites, and procedures for automatic rights management of depositors' intellectual property.

What is the **what** that they currently deliver? A brief

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survey of commercial sites at the end of 2000 [1] found a true paucity of classical sheet music. Among the titles offered, files containing more than two pages (excepting the presentation of scanned images with no underlying intelligence) were nearly non-existent. MIDI transposition features were extremely weak (reflecting the limitations of MIDI data as a foundation for musical notation). The value to serious musicians, students, teachers, and scholars could be generously described as negligible. Far more value could be found at sites without commercial aspirations (e.g., *cpdl.org*). The quantity of recognized classics and the quality of the contributions and of file-quality control are, ironically, much better (given judicious searching) than anything the commercial world currently provides. Time and experience will likely change the balance, but the gold rush of commercial enterprises into the fray of e-commerce appears to have caused many front offices to ignore the perils of working directly with the musical data which underpins all score production by computer. It is to this subject that I will devote the balance of this presentation.

3. The Aims of the *MuseData* Archive

A discussion of social values in the traditional enterprises of music publishing may seem an odd way to introduce a technical discussion of musical details, but these underlying social values and the communities from which they issue have always been at the heart of our interest. The *MuseData* project, initiated by Walter B. Hewlett in 1984, has aimed to distribute scores electronically from the beginning. Our orientation is what might be termed a wholesale one: we want to make all standard repertory available at low or no cost for use by non-profit entities (schools, conservatories, universities). Commercial enterprises offering value-added features are welcome to use the data under license.

What differentiates our project from others is that we have always viewed the creation of notation files simply as one end-use of the data. Our aim has been to make data available in as many formats as would be useful in diverse application domains. We count among these sound, notation, and analysis. As we showed in *Beyond MIDI* [8], applications in each domain require a somewhat different set of musical attributes. If one encodes only for sound, poor notation will result. If one encodes only for notation, it will be difficult to extract aesthetically viable information for sound (e.g., for timbral and dynamic effects, for articulation, and so forth). Our data is therefore not limited in what it represents to only those attributes of music particular to notation. The features required for notation are simply one selective subset of the data, just as the features required of Standard MIDI files are another selective subset of the data, and the features required for the use of **kern files (for analysis with the *Humdrum Toolkit*) another selective subset.

4. Data-Convertibility Issues

How does one serve such an array of potential application areas from one set of data? Ideally, it has long been imagined that the magic bullet for all kinds of music applications would be an interchange code that would magically transform any data set produced for one application into a data set suited to another. What the dream of such an interchange code overlooks is (1) that each application may require a slightly different set of attributes and (2) that applications make somewhat divergent assumptions about the organization and requisite content of musical data. That is, while hierarchical models are the norm in the processing of data files for notation, the construction of hierarchies can be extroverted or introverted (parts may drop out of encoded scores; scores may be assembled from encoded parts). Current experiments with XML schemas for music will determine how troublesome these variant arrangements are in actual implementations. See Table 1.

Three obstacles to reliability and efficiency affect the operation of notation software. (1) Musical data cannot be highly generalized and therefore does not conform well to processing designs which assume a high degree or regularity and predictability. (2) "Corner cases" (content which defies uniformity or predictability) may only amount to 1% of the data, but the negative effect on efficiency or comprehensibility may be disproportionately great. In musical contexts a 1% error rate is likely to be distributed relatively evenly over most files, rather than concentrated (as would better suit programmers) in one totally wrong file complementing 99 error-free files). The number of files that requires some intervention is a substantial portion of all files. The intervention will consume not 1% of the total effort but all too often as much as 150% of it. (3) If one system lacks 5% of the attributes for an intended domain and another system lacks 3%, the format with the greater number of attributes rarely subsumes all the attributes used by the other format. For all these reasons, a score-production system must be extremely reliable and its goals clearly addressed before it can be of any value at all.

Classical music poses its own challenges. The works are much lengthier–close to 100 pages (8.5" x 11") for some symphony scores, 300 pages or more for an opera score (c.2,000 pages when all the short scores and individual parts are added). For those who wish to avoid the drudgery of data entry and the onerous task of data verification (i.e., old-fashioned human proof-reading), it is preferable to work from a previously verified core data set which may be re-edited as required by changing tastes, new interpretations, and of course the discovery of new sources for a particular work. Such capabilities could go a long way in furthering the traditional aims of publication bodies while diminishing the costs of score origination.

Such statistics seem to intimidate those who want to start with the data rather than the still unencoded music. Yet fear of the labor of encoding has led to repeated efforts to establish a standard method of interchanging files from one data format to another. Preliminary discussions of encoding systems and their various strengths and weaknesses vis-à-vis interchange schemes has proved a stimulating subject, one discussed at length over the past decade in *Computing in Musicology*, the *Computer Music Journal*, and elsewhere.

The resulting products (SMDL, NIFF) have had mixed receptions. There are many possible reasons for this. Proprietary interests have militated against the adoption of interchange schemes; each commercial vendor has tended to insist on the supremacy of his own scheme and the "lack of need" for an interchange. Standard software developers face a situation far more complicated than front offices imagine, though. They must determine which of the three codes (input, interchange, output) caused the bug and whether it is fixable or implicit in the structure of the data or an incompatible chemistry of codes. They may need to bullet-proof their own code to deal with deficiencies of the still evolving interchange code. The interchange code will be very difficult to debug if it is written all at once rather than incrementally.

While XML schemas have breathed new life into the quest for an adequate interchange format, they still must deal with two widely recognized issues: (1) encoding schemes (being application-driven) are not comparable in their selection of features; and (2) notation programs, while all assuming some hierarchy of features, are not uniform in the data-architectures that they assume. In the hypothetical System 5 of Table 1, for example, the need for time-ordered and score-ordered cross-views in a superset becomes apparent.

System 1	**System 2**	**System 3**	**System 4**		**System 5**
	key signature		key name, key signature		
ticks/minute	meter signature	ticks/minute	meter signature		
ticks/quarter note					
key number continuum	pitch name continuum	frequency number	pitch name class (A..G)		
			octave number		
	inflection implied by key signature; exceptions noted		inflection explicit for every note		
absolute time on	duration (relative to meter signature)	time on	stated duration	implied duration	
absolute time off		time off			
velocity	dynamics (as labels)	user-controlled dynamics	dynamics labels	dynamics (scope)	
instrument (channel)	instrument label	instrument number	instrument label	articulation type (normal, legato, plucked, etc.)	
		absolute amplitude			
		relative amplitude of harmonics			
	articulation marks	duration modifiers for simulated articulation			
	ornament signs	realized ornaments	ornament signs	ornament real-ization formula	
	stems, beams, slurs, marks generated by software (or ignored)		stem direction		
			beam type		
			slur orientation		

Table 1. Attribute dependency in diverse representation schemes: (Col. 1) hardware interchange of signals (Standard MIDI Files), (Col. 2) musical analysis (e.g., elastic instantiations in the *Humdrum Toolkit*), (Col. 3) sound generation (Music V), (Col. 4) combined encoding for notation, sound output, and analysis (*MuseData*); (Col. 5) symoptic view of potential complexity in a neutral interchange code representing the whole accumulation of features of the other four systems.

5. The Data-Interchange Model

To judge from MIDI-file sites, the trend on the Web is to create files for the same works over and over. In the sound world, this makes sense: the Web has enabled many a gifted amateur to demonstrate his or her skills in audio editing and musical arrangement. Graphic editing for editions raises much more fundamental questions. For example, information which is articulate in one domain may be quite inarticulate (or alternatively quite unnecessary) in another. Better fits between systems can be achieved by remaining within one application domain (the NIFF effort was originally focused exclusively on interchange within the notation domain.) That interchange codes have so far not fulfilled the potential many once foresaw for them does not suggest that they cannot do so in the future.

Non-convertible data is, of course, what traditional music publishers think they want. Although translation presents many obstacles, from a technical point of view there is no such thing as an untranslatable code. At the system level, all musical data can be converted to another format, even if certain specific details are missing. Fearing the Napster-like production of copies, music publishers seem slow to realize that new business domains inhere in simultaneous support for multiple data formats. For example, the data set that is used to produce a collected edition of all the works of Composer X (e.g., Wagner or Verdi via SCORE, Vivaldi via *Finale*) could also serve (if it is sufficiently feature-rich) as a basis for empirical (as an opposed to anecdotal) analyses of music.

6. The Encode-Once, Write-Many Model

Having begun at a time when no efforts to devise an interchange code were in evidence and when Standard MIDI Files had not yet been devised, CCARH did not count on the availability of interchange codes. We concentrated instead on determining what features would be essential for applications in all three application domains (sound, notation, analysis) and in the repertories we principally planned to encode (music of the eighteenth and nineteenth centuries). It quickly became evident that some features required for one application would be in conflict with features required for another. For example, a grace note for notational purposes would need to have no time value (since it is not "counted" in the arithmetic of measures), while a grace note for sound would need an explicit time value declared at onset (otherwise it would not be heard).

Little by little, double methods of representation (giving added sound-specific and print-specific enhancements in parallel) accrued to *MuseData*, resulting in the bifocal arrangements seen under "System 4" in Table 1. The plan was to translate directly from our host code (*MuseData*) to whatever client codes seemed useful. We translate only to codes which are openly documented, since research applications dependent on closed codes present serious obstacles to scholarly communication and continuity.

Since 1992, we have concentrated our data-translation efforts on (1) MIDI (for sound), (2) SCORE (for notation; for data development we use an in-house notation program), and (3) *Humdrum*'s **kern (for analysis). MIDI and *Humdrum* contain no spatially-oriented data; SCORE contains no sound or "logical" data (an instance of logical data would be first and second-ending information that should be "realized" in sound or the analysis of form but handled without full restatement in notation). Additionally we have translators to graphics formats such as TIFF, GIF, and PDF.

MuseData itself has been translated by third parties to other codes including those used by *Finale* (directly and via **kern), to *Nightingale*; to Braille music notation [2], and to various XML schemas ([3], [4], [6]). Data in various codes devised for research but supporting simple display and printing schemes (EsAC, *Plaine and Easie*) have been translated in *MuseData.* The complex relationships that now exist between *MuseData* and other codes are shown in Figure 1.

7. Human Efficiencies in and Obstacles to Data-Translation

The shocking truth about musical-data translation is a well-kept secret: given programmers with a high degrees of experience in musical-data translation and literacy in the visual grammar(s) of musical notation, some musical-date translation programs can be written in a matter of days (i.e., much more quickly than interchange codes can be debugged). By comparison the little-used SMDL (approved in 1997; se [9]) took twelve years and approximately 36 three-day meetings attended by, typically 10-15 people, plus much additional programming time to pass from a vague idea to an ISO-approved "standard." NIFF (informally adopted in 1996; see [5]), based on pre-existing software by Cindy Grande for the translation of bitmapped images, formally took two years of discussion (conducted primarily over the Internet) by five or six key people.

Direct translation between codes is highly efficient in terms to data integrity. Code-to-code-to-code translation (that is translation schemes involving an intermediate representation) is prone to slightly reduce the number of features represented in each new output, since there is no perfectly orthogonal match of features between any two codes. For some applications this is acceptable, but musical notation is by and large unforgiving. Users have a ready eye for violations of visual grammar and missing symbols.

What is most inefficient in our own operation, and will inevitably be inefficient in most systems involving any kind of data translation, is that the result of each translation requires its own verification stage. The only way to verify sound data is by listening–in real time; the only way to verify notational data is to print it out and inspect it carefully. Syntax-checking of analytical data cannot be fully carried out, but wholesale processing will usually reveal widespread bugs quickly.

Regarding efficiencies overall, the greatly ignored statistic is the amount of time that accurate data encoding takes. In our enterprise about .5 man-years would be required to encode fully an opera or oratorio that would take three hours in performance. Given that this includes the creation of a complete data set, the production of full scores, short-scores, and parts, and translation into multiple data formats, it has much to offer over the traditional methods of typesetting that are still in use in some quarters. The number above must be understood to come from highly experienced, musically literate staff who are thoroughly familiar with the tools they are using. (We speak from experience, have undertaken more than a dozen opera projects for professional performances.)

Optical recognition software is not yet a viable alternative ([7] gives comparative statistics on manual and optical data-acquisition methods). Only modest incremental improvements seem to have occurred since our survey of seven years ago. Debugging optically scanned data is extremely time-consuming because scanning software makes non-human errors which human beings are poorly trained to detect (the analogues of confusing in text a "1" and an "l"); the graphical similarity is not matched by symbolic similarity of underlying code. Software focused on musical notation has always shown the same work pattern: rapid initial progress towards a tentative working model followed by a a lengthy period of continuing but progressively slower improve-ment, as the problems of "corner-cases" are one by one identified and resolved.

8. Inherently Musical Obstacles to Data Translation

The essentially musical problems most commonly encountered in the translation process fall into predictable areas. In the translation from *MuseData* to ***kern* (undertaken by Bret Aarden, Andreas Kornstaedt, and Craig Sapp), the following differences were the most demanding in terms of attention required by small details and exceptional cases:

8.1. Resolving differences of data organization in the host and client formats. To go from *MuseData* to ***kern*, for example, it is necessary to go from a serial organization (encoded parts, each in a separate file for each movement) to a parallel one (all parts assembled side-by-side in a single score file). This is problem-atical in pieces where the number of Humdrum spines changes.

8.2. Harmonizing different conceptions of musical process. The Humdrum class of representations permits spines (parts) to split in pseudo-polyphonic textures, such as those of Baroque preludes. *MuseData* encodes each thread as a separate voice but accounts for each voice only to the extent that it is sounding. Thus if in a 60-bar work three voices only are identified in the first 30 bars but then three more voices have staggered entries in Bars 31-40, only to disappear for the remaining 20 bars, Parts 4, 5, and 6 will show data only in the relevant bars. Because all parts are present throughout a movement and/or piece in ***kern*, it will either show Parts 4, 5, and 6 as running throughout the 60 bars (with "pad" characters in the bars in which they are silent for congenial processing with grep) or it may, alternatively, show the first three tracks each splitting into two spines for the passage that is texturally richer, and then contracting again into three spines for the last 20 bars.

8.3. Controlling the vertical analogue of #2. When visual bar-lines (e.g., in the case of *da capo*s introduced by double-dotted repeat signs) are not coincident with logical bar-lines, many problems of beat interpretation can occur in the assembly of virtual full scores. Measures that appear to be incomplete (including initial measures containing only pick-up beats) are often most easily translated by padding them to their ostensibly full value, but in notation they may produce undesirable rests and in analysis they will produce redundant measures. Conversely, in relating scores to parts, parts within scores will normally be "padded" to fill the page, although parts that are silent for many pages may be eliminated to save vertical space. The long silences may be represented in individual parts with multi-bar rests indicated by a single symbol. The re-entry may be signalled by a passage of arbitrary length from anotherh part shown in cue-sized notes. The details do not yield easily to algorithmic solutioins.

8.4. Compensating for missing attributes. No matter how comparable systems may be in most respects, some features present in the host format may be missing from the target format or vice versa. In translating from *MuseData* to *SCORE*, for example, tie information is lost because SCORE, being graphically based, does not make a logical distinction between ties and slurs. In translating from *MuseData* to ***kern*, editorial comments in the former (which may exist at 36 levels in the host format) are filtered out. Some editorial comments explain a double encoding (to accommodate data "as presented" graphically and data "as intended" logically or in sound) in the host. Some detail discrepancies between musical sources.

9. Distribution and Use of Performing Materials: A Cultural and Economic Perspective

Our current activities are concentrated in the non-profit sector. In countries such as our own, the lack of government support for the arts sets our environment apart from that of our European colleagues, who can usually count on well established work-flow patterns stabilized by long-standing (even if declining) funding patterns, clear lines of authority, and quality controls rooted in the practices of academic societies, national libraries, university and conservatory curricula, and directorates of performing organizations. While European governments are perhaps not as generous in their support for musical performance as they were 20 or 30 years ago, specific repertories are still considered to forms part of national cultural identities still considered to be worth preserving.

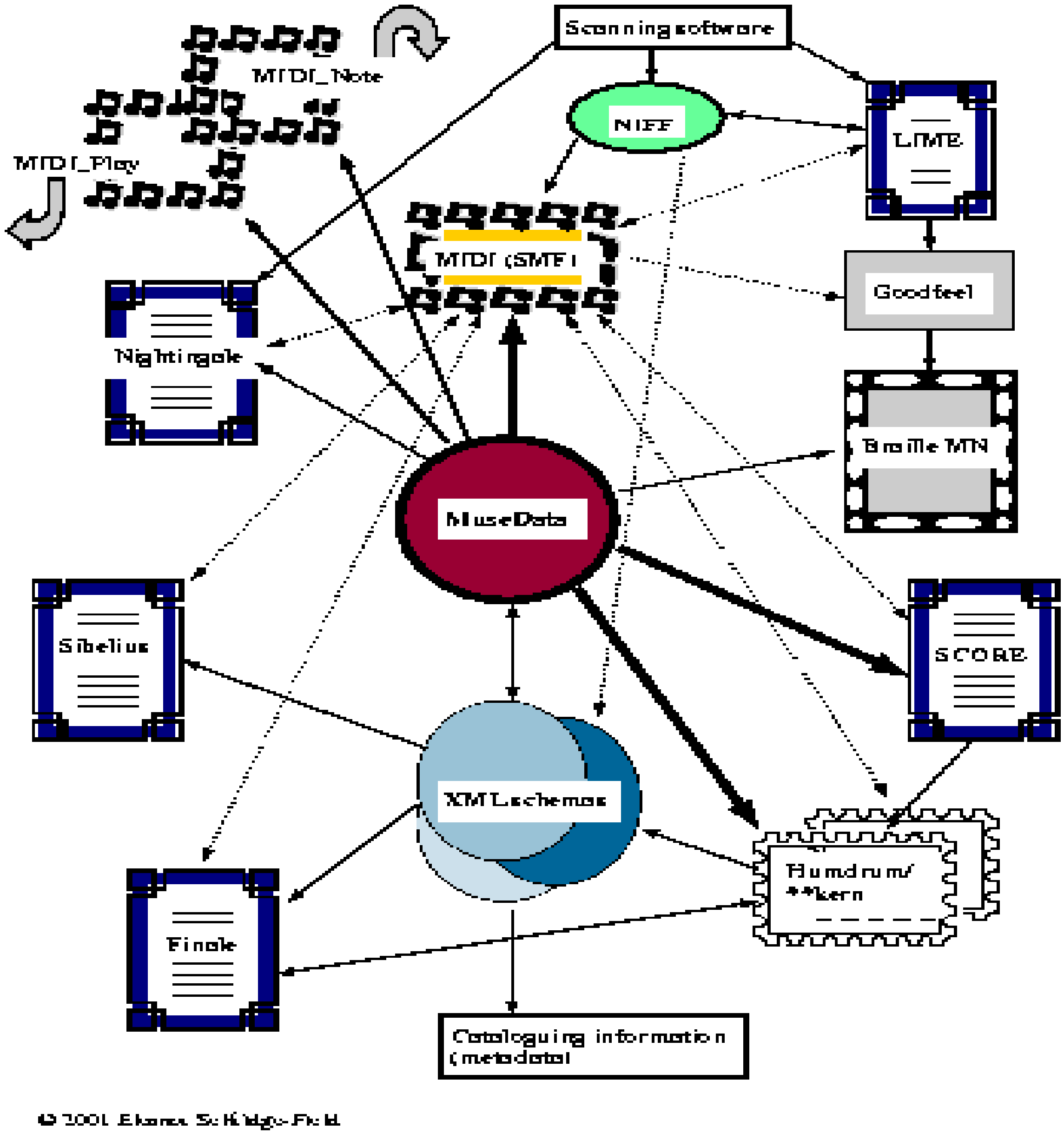


Figure 1. Current status of direct-translation capabilities affecting musical scores (March 2001). Portrait-mode rectangles represent music-notation programs. Items with eighth-note borders representing various kinds of MIDI files. Interchange codes are elliptical. Miscellaneous software functionalities (data associated with scanning, cataloguing, and analysis software) are in landscape-oriented rectangles. Translations from *MuseData* (round) carried out in-house are shown by heavy pointed lines. Third-party translations are shown by lighter pointed lines. Automatic data translations (chiefly to and from Standard MIDI Files) are shown by dotted lines. The left-pointing fat arrow from MIDI-Play indicates data optimized for input to sound software, while the down-pointing fat arrow from MIDI_Write indicates data optimized for input to notation software.

Differences of culture and economy are particularly evident in relationships between European publishers and performing organizations in the U.S. Performing organizations in the U.S. rarely recoup more than 50% of their operating budgets from ticket sales. They are all dependent on private donations of equal or greater value than ticket sales. Record production typically produces a further deficit. For a major work, such as an opera or oratorio, the costs of record production alone (perhaps $10,000 for sound engineering and $20,000 for recording rights from a major music publisher) generally discourage commercial recording of any kind. Thus from a financial perspective, the performing and recording rights which the rental of parts has traditionally protected is unaffordable for all but the largest performing venues. Ultimately the monies that provide these rights must be sought from the non-profit sector (foundations and private individuals of substantial means). U. S. copyright law was conceived "to stimulate creativity," but the social practices which have grown up around it often have the reverse effect. The principal reason performing organizations give for recording at all is that the availability of recordings helps to establish a group's name and sometimes to increase audiences for live concerts (leaving a concert deficit of 50% rather than 60% or more).

When the print and performance cultures attempt to interact in the arena of music publishing and performing rights management, animosities quickly surface. European presses control most of the best editions of the core classics. Profits are under pressure for many reasons, not least of them a diminishing market worldwide for classical music and a progressive narrowing of the definition of the term "standard repertory." For some scholarly editions which have been in progress for as long as half a century, performing parts are no longer viable economically. The effort that goes into their production seems doomed to decay on library shelves.

There is no diminution in the number of scholarly editions being produced, however, nor is there any lessening of commitment to the highest principles of scholarly editing. Yet an unfortunate gap is occurring: scholarship seems to be more and more consigned to the cul-de-sacs of the print world, while available materials come more and more often from casual, sometimes even inconsistent or chaotic methods of acquiring content (e.g., via optical recognition or feature-poor MIDI files). No musician who values quality of content can greet what little classical music commercial sites provide with much enthusiasm. The distribution channels may be broad, but if the quality is appalling and the quantity minuscule, no useful need is being served.

10. Differential Distribution of Printed and Virtual Materials: A Practical Perspective

We believe that our model of distribution is elastic enough to complement the changing nature of these kinds of projects in several ways. A few examples are these:

(1) Since 1996 we have been working with Dover Editions, Inc., a major source of study scores in the U.S., to generate from our data archives (a) camera-ready copy for editions which for contractual (rather than technical) reasons are distributed in print only under Dover's imprint and, simultaneously, (b) parts and analytical data for the same works which are distributed from our Website. To date we have made available the parts for the 24 concertos in two Vivaldi's most popular opuses (Opp. 3 and 8, the latter containing "The Four Seasons") and other projects are planned. [See *www.ccarh.org/publications/*]

(2) The XML translations of *MuseData*, which is based on the same out-of-copyright editions as those reproduced photographically by Dover, offer the prospect of works such as Handel's *Messiah* (in nine versions!) becoming available in formats suited to popular notation programs such as *Sibelius* and *Finale*, thus enabling performers to re-edit the files to suit their needs (see again Figure 1.)

(3) *MuseData* files which are not derived from out-of-copyright editions represent new editions requiring the editor's written permission for both performance and recording. Once the editor's consent is obtained, scores and parts can be made available—on paper—at modest cost. In essence, this procedure amounts to a third model of distribution.

(4) A fourth model was proposed by one of our German colleagues a few years ago. The gist of his idea was that publishers of scholarly editions should assume the role of distributing analytical data (on request, for a fee) as a supplement to the large printed collections they now produce. The publisher did not respond to the proposal, despite the fact that the scholar who proposed it had already created the translation software that would have made it easy to implement.

(5) Fifteen years ago we believed that the ideal relationship of enterprises such as ours to music publishers would have rested on the licensing of electronic rights. We would have preferred at that time to encode in-copyright versions of collected works, because they would have offered the most advanced basis for analytical applications. Publishing operations that now seem outdated and economically inefficient could have raced ahead of the pack, had they been receptive to the idea. Those we talked to then have preferred to go their own ways, with the result that some are still have no unified data set for the works they have produced over the past 15 years. (Large-scale computer typesetting of musical scores can be dated to 1977, when A-R Editions, Inc., using software by Tom Hall, produced two volumes

of the music of the Venetian composer Dario Castello, thus initiating a series of publications which now numbers in the hundreds). It is important for them to realize that notation-software vendors are rapidly taking control of their territory.

Scholars and performers are ill served by the reluctance of publishers to enter the world of core data sets. Scholarly bodies labor for decades to produce editions for which no analytical data may ever be made available to them; performers increasingly serve as their own editors, to the dismay of learned editors. Many, in fact, have established their own means of distribution. Composers similarly have devised many ways of being directly in charge of the distribution of their works. The B2B model of electronic commerce may simply never work for musical scores, but time will tell.

11. Outlook

As we look forward to the next decade of activities in score production and distribution by computer, we expect (with regret) that many works will be encoded over and over again. The more the same works are encoded repeatedly, the less energy will be directed towards more challenging and rewarding goals–those of improving computer-based editing techniques, raising the level of editorial discrimination of Web users, refining the technical possibilities for virtual editions, and linking up online editions with the powerful meta-data archives that music librarians have spent decades developing. The sooner we overcome the write-many, use-once attitude, the sooner we can move on to these new challenges.

References

[1] Anthony, D., C. Cronin, and E. Selfridge-Field. "The Electronic Dissemination of Notated Music: An Overview," *The Virtual Score: Representation, Retrieval, Restoration* (Computing in Musicology, 12 [2001]), 135-166.

[2] Brown, S. "An Extensible System for Conversion of Musical-Notation Data to Braille Musical Notation," *The Virtual Score: Representation, Retrieval, Restoration* (Computing in Musicology, 12 [2001]), 45-74.

[3] Castan, G. "NIFFML: An XML Implementation of the Notation Interchange File Format," *The Virtual Score: Representation, Retrieval, Restoration* (Computing in Musicology, 12 [2001]), 103-112.

[4] Good, M. "MusicXML for Notation and Analysis," *The Virtual Score: Representation, Retrieval, Restoration* (Computing in Musicology, 12, [2001]), 113-124.

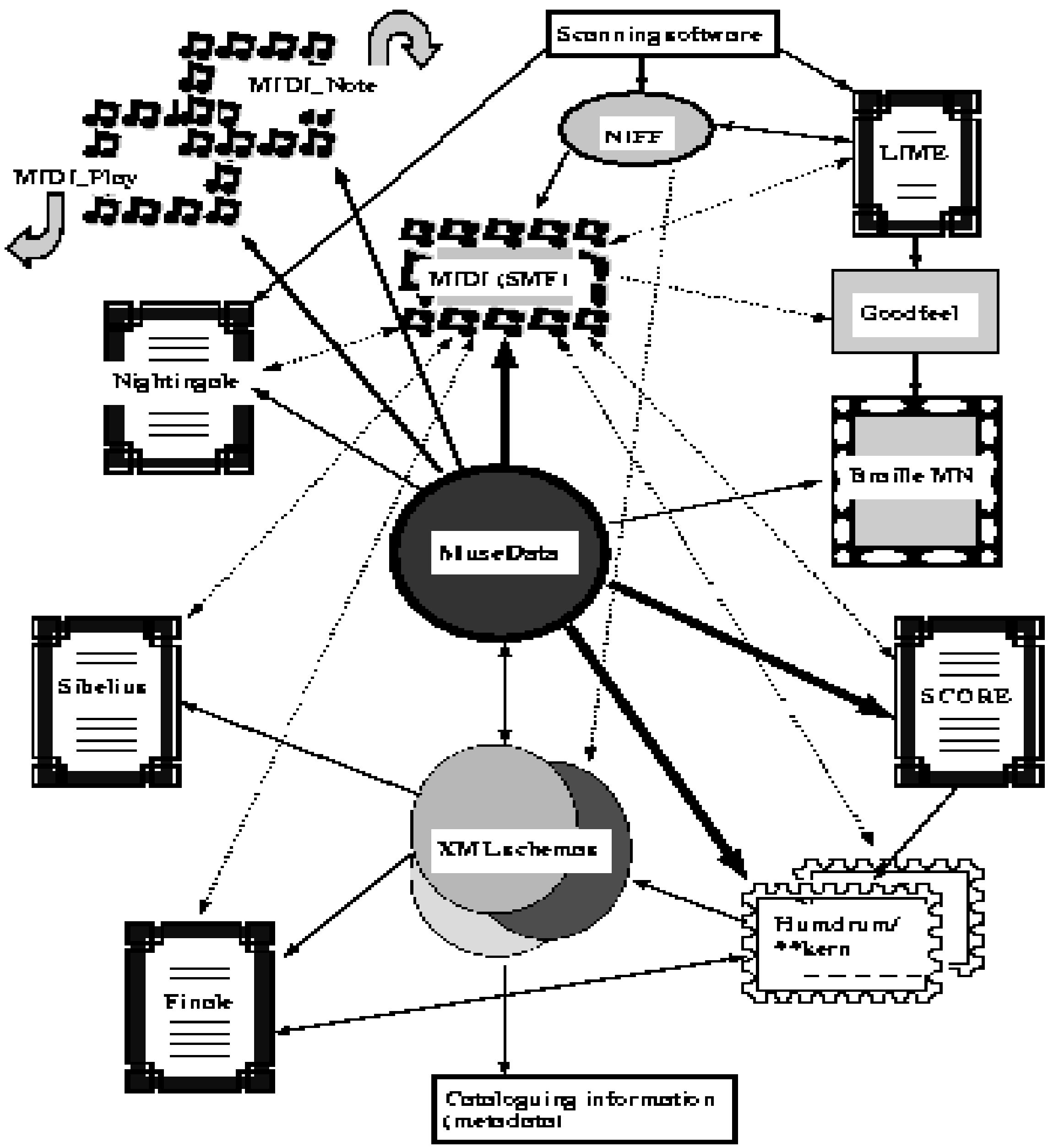
[5] Grande, C. "The Notation Interchange File Format: A Windows-Compliant Approach [to Interchange Codes]" in *Beyond MIDI* (1997), pp. 491-512.

[6] Roland, P.. "MDL and MusiCat: An XML Approach to Musical Data and Meta-Data," *The Virtual Score: Representation, Retrieval, Restoration* (Computing in Musicology, 12 [2001], 125-134.

[7] Selfridge-Field, E.. "How Practical is Optical Music Recognition as an Input Method?" *Computing in Musicology* 9 (1994), 159-166.

[8] Selfridge-Field, E., ed.. *Beyond MIDI: The Handbook of Musical Codes*. Cambridge, MA: The MIT Press, 1997.

[9] Sloan, D.. "HyTime and Standard Music Description Language: A Document-Description Approach [to Interchange Codes]" in *Beyond MIDI* (1997), pp. 469-490.


Scanning software
NIFF
LIME
MIDI_Note
MIDI_Play
MIDI (SMF)
Goodfeel
Nightingale
Braille MN
MuseData
Sibelius
SCORE
XML schemas
Humdrum/
**kern
Finale
Cataloguing information
(metadata)