A System of Formal Notation for Scoring Works of Digital and Variable Media Art

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Abstract

This paper proposes a new approach to conceptualizing digital and media art forms. This theoretical approach will be explored through issues raised in the process of creating a formal declarative model for digital and media art. This methodology of implementing theory as a way of exploring and testing it is intended to mirror the practices of both art making and computer processing. In these practices, higher-level meanings are manifested at lower levels of argument, symbolization, or concretization so that they can be manipulated and engaged, resulting in a new understanding of a theory or the formulation of new higher-level meaning. This practice is inherently interactive and cyclical. Similarly, this paper is informed by previous work and ideas in this area, and is intended to inform and serve as a vehicle for ongoing exchange around media art.

The approach presented and explored here is intended to inform a better understanding of media art forms and to provide the lower level 'hooks' that support the creation, use and preservation of media art. In order to accomplish both of those goals, media art works will not be treated here as isolated and idealized entities, but rather as entities in the complex environment of the real world where they encounter various agents, life-cycle events, and practical concerns. This paper defines the Media Art Notation System and provides implementation examples in the appendices.

1 Digital / Media Art and the Need for a Formal Notation System

Digital and media art forms include Internet art, software art, computer-mediated installations, as well as other non-traditional art forms such as conceptual art, installation art, performance art, and video. It is important to point out the inclusion of digital art in the approach explored here because of its unique nature, even among media art forms, and because of how digital informatics informs models that may apply to all the above art forms. It is also important to note that the types of works discussed here are not limited to the traditional meaning of "media" art as analog, electronic media (i.e. video, film, audio, and electronics). Here, media art is intended to include digital art and other variable media art forms.

These art forms have confounded traditional museological approaches to documentation and preservation because of their ephemeral, documentary, technical, and multi-part nature and because of the variability and rapid obsolescence of the media formats often used in such works. In part due to lack of documentation methods, and thus access, such forms do not often form the foundation of research and instruction. In many cases these art forms were created to contradict and bypass the traditional art world's values and resulting practices. They have been successful to the point of becoming victims to their own volatile intent. Individual works of media art are moving away from all hope of becoming part of the historic record at a rapid rate. Perhaps as important, the radical intentionality encapsulated in their form is also in danger of being diluted as museums inappropriately apply traditional documentation and preservation methods or ignore entire genres of these works altogether.

A new way of conceptualizing media art is needed to serve the needs of documentation and preservation as well as other activities that surround media art such as education and collaborative creation. New projects from the artistic, academic, and museum communities are being formed to address these needs. This paper is a direct outgrowth and continuation of the efforts of two such projects, Archiving the Avant Garde (1) and the Variable Media Network (2). Other papers summarize the broad efforts undertaken by these projects such as best practice strategies for file and media storage, compatibility with preservation framework standards such as Open Archival Information Systems (OAIS)(3), and controlled vocabularies. This paper will focus on the development of a formal notation system for media art. It is best to begin by introducing the concept of a formal notation system and score in the context of media art.

Media art is as much performative or behavior-centric as it is artifactual or object-centric. Media art has variable form much like music. A single musical work can be performed using different instruments or hardware each time. As long as the essential score performed is the same, the musical work itself will be recognizable and retain its integrity. A work by Bach can be performed on a relatively modern piano as well as on a harpsichord for which many of Bach's works were originally created (in fact these works can be performed on a computer or synthesizer). Even on the piano, we recognize the work and its creator; we consider it to be authentic. Media and especially digital art are also variable from the moment they are created. The logical is separate from the physical. They may be authored on one brand of computer hardware and software platform, but presented under a very different configuration. For works of Internet art, aspects such as color, scale, and speed can vary significantly when viewed on different monitors over different network speeds. This variability is not considered corruptive but rather an inherent property of the medium and the work. Digital art will almost certainly use different hardware for presentation or performance a hundred years from now, but it can still be considered authentic.

Given the similar variability between music (and other performing arts) and media arts, it is appropriate to consider a mechanism like a score for binding the integrity of media art works apart from specific instruments. What would a score for media art look like? For digital art, code itself acts as a score - a set of instructions that trigger actions or events much the same way as musical notation. However, computer code as implemented currently is still too environment-specific, operating differently under variable conditions such as operating system or hardware. This would be like musical notation working for one brand of Tuba, but not another, or working in a concert hall with a certain color carpet, but not others. Computer code is closer to fingering instructions than to musical notation. A system of formal notation for media art should be abstracted from environment and as robust as musical notation. Further, a formal notation system must accommodate media art works that are not digital and it should be legible well into the future independent of the media it is intended to preserve. For these reasons, notation for media art should be human-readable with less interpretation than is required for computer code.

It is important to note that systems of formal notation for media art and musical scores are analogous, but not identical. Musical scores admittedly embody complex relationships to the works they transcribe, and are often open to a wide range of interpretation. The reason that musical scores provide a useful model for media art notation is that they comprise the clearest type of description that compiles formalized (systematic) discrete elements into documents that aid in the re-performance or re-creation of works of art. This core function is independent of the cultural roots of any given notation system. Musical scores also demonstrate how to navigate the border between prescription (maintaining the integrity of the work) and the variability that is inherent in media art. Formal notation systems necessarily embody trade-offs in their level of abstraction from implementation; too abstract and they lack capacity for integrity, too prescriptive and they lack portability and robustness. So, a media art score would share the goal of a musical score not to provide the perfect recipe, but the best possible one.

The development of a system of formal notation for media art first requires the development of a conceptual model. The formal notation system could be considered an expression of that model and a score considered a specific instance of notation. It is important to note that the conceptual model and expression format are distinct entities. For instance, this conceptual model could be expressed using various formats such as Extensible Markup Language (XML)(4) or a database file. In this way the conceptual model itself defines the integrity of the score while allowing for variability in its expression. The conceptual model could be considered a kind of meta-score.

This new conceptual model and notation system could be used: to aid in preservation of media art works; for their re-creation in the future; as a record format; as an architecture for media art management databases; as a framework for online public access catalogs of media art; for educational and community forums dedicated to media art; and as a framework for generative and collaborative artist networks like the Pool at the University of Maine (5).

For the semantic web community, this conceptual model and expression format comprise an ontology. For the digital library and broader cultural informatics communities, it comprises a metadata framework. For our purposes here, it is a system of formal notation for scoring works of digital and media art that could serve the needs and uses listed above.

2 Requirements for a Formal Notation System

The first requirement of a system of formal notation for scoring works of media art is that it is appropriate to the content and purposes it is intended to serve. In this context, it must reflect the nature of media art. It must be able to describe the artwork not just as an object or collection of objects, but also as an event or activity (or any combination of these) that may include human as well as automated actions. It must accommodate not just the declaration and location of files and objects, but also the explicit declaration of behaviors, interactions, choices, contingencies, and variables. This formal notation system may not describe the artistic process per se, but should be able to describe the work as set of intents expressed as parameters and manifested as a product or occurrence. It should be descriptive of levels of agency and choice within the work, allowing for a continuum of assignable human or automated roles from creator to user.

A specific document instance of the notation system - a score - should comprise a guide to aid in the re-creation or re-performance of the work. A test of the notation system is that one should be able to compose directly within it, defining and possibly creating an artwork from scratch. If one cannot compose directly in a system of notation then it is a recording system and would not comprise a guide to the re-creation of the work.

A formal notation system must be capable of describing all digital, all physical, or hybrid art works. It should be able to describe not just the aggregate work, but also make explicit the structure of sub-components of the work. Details such as technical data, creator info, rights info, and related choices may vary between different parts of a work.

A notation system should provide broad interoperability with other descriptive and technical standards that digital media art interacts with, including cultural informatics, library and museum standards, and media industry standards. This is needed so that scores for media art works do not become marginalized and can instead easily co-exist alongside traditional art records within systems that span many art forms. Though standardized, the notation system should be robust and flexible enough to allow for local descriptive practices within the overall framework.

The notation system should employ an expression format that is robust and standardized so that the development of software tools, training, documentation, and support is feasible for the arts community and leverages larger community or industry efforts. To allow durable and transparent scores, the notation system should integrate both human-readable (natural language) layers that allow high-level functionality and machine-readable (artificial/encoded language) layers that allow for automated processing.

A notation system should be practical, cost-effective, scaleable, and tractable. It should allow varying levels of implementation from minimal scores to complex scores that are expanded upon at various points in the life cycle of the work. Including these concerns results in a more useful and accurate conceptual model by addressing media art works not as abstract and isolated entities, but rather as entities in the complicated context of the real world.

3 Survey of Related Work

In addition to the aforementioned projects this paper builds upon, there are other projects with similar goals or subject matter. This overview of related work is not comprehensive, but cites projects that have the closest parallel or influence on this paper. This survey will draw out the similarities and differences between approaches for comparison.

3.1 Preservation and Archival of Newmedia and Interactive Collections (PANIC)

Jane Hunter and Sharmin Choudhury of the Distributed Systems Technology Center in Brisbane Australia present their goal in "Implementing Preservation Strategies for Complex Multimedia Objects" (6). " The goal is to investigate alternative approaches to the archival and preservation of mixed media objects and determine the optimum approaches for ensuring their longevity and to facilitate their redisplay."

This research addresses broadly defined media objects, but utilizes media art works as the primary case studies. Hunter and Choudhury outline a solid strategy in many respects. They promote the use of existing standardized metadata schema that leverage previous cultural and industry efforts. These standards include Metadata Encoding and Transmission Standard or METS (7), and the Synchronized Multimedia Integration Language or SMIL (8). They also propose a layered preservation strategy that accounts for uneven availability of documentation, metadata, and original files for media objects.

Hunter and Choudhury recommend the use of METS encoded documents to contain descriptive and administrative metadata about the work, while linking to SMIL encoded files that describe the structure of the work.

However, it is difficult to encode the structure of a work in SMIL without manually re-creating the work entirely. SMIL is not scaleable because one cannot create a 'rough draft' of the work's structure to be completed at a later date. This strategy also assumes some of the liabilities of SMIL for this purpose (a more detailed analysis of METS and SMIL is included below). This strategy is not without its merits. It would certainly be attractive if, in the future, software tools can automatically convert between many of the popular applications or programming languages and standardized formats like SMIL (in the way that some proprietary CADS programs can now "save as" standardized VRML format).

Hunter and Choudhury recommend the use of several "behaviors" that have been defined in the Variable Media Network as "types" or broad genre classifications for media art works (a list of these behaviors is included in Appendix 2 of this paper). This is an innovative and entirely appropriate use for these behaviors. These behaviors have previously been applied to describing whole media art works when they might be even more useful if applied to individual sub-components of works.

Hunter and Choudhury state that the strategy of computer emulation is overkill for archiving works of media art. A full discussion of the merits of emulation is out of scope for this paper, but it is useful for the current effort to reveal the foundations of this argument. Hunter and Choudhury cite an article by David Bearman (10) in which he states, “The hope that emulation could be a viable strategy for preserving records (except for those records which are themselves executable code), is not viable.” These ideas stem from the solid library or record oriented preservation perspective that data (content) can be separated from systems (specific software and hardware). In this model, data should be migrated for the long-term, while systems are time-bound and disposable. Bearman's statement echoes these ideas with the one caveat that some records may themselves be, or behave like, systems. This caveat describes much media art, and thus an argument that is clear and recommendable for records may not apply to media art (it should be noted that Bearman was not writing about media art in the source document for this quote). The separation of content from systems is a strategy that would seem to mirror the notion of a score for media art. However, the significant difference is that during the split of content and systems, the library model often places associated behaviors and functions on the side of disposable systems. Where media art is concerned, the content/systems split should place behaviors on the side of content in need of preservation. Emulation is one way to accommodate this by retaining the systems, but there are other ways detailed below as well.

However one considers these few elements of PANIC research, PANIC represents innovative and important work in this field. PANIC points out the real need for software tools for preserving of media objects. In addition to adopting an existing SMIL tool, PANIC developed a new online tool for creating complex METS XML documents. This practical need has been addressed in other cultural informatics projects as well. For instance the MOAC project developed the Digital Asset Management Database (11)(it would seem there is some urgency being encoded in the acronyms here; PANIC, DAMD). DAMD converts art and museum metadata into standardized XML formats ranging from METS to Encoded Archival Description (EAD)(12). Tools are an important consideration because without tools and other mechanisms for implementing our conceptual models, we are left with far fewer options for testing these models.

3.2 Capturing Unstable Media Conceptual Model (CMCM)

CMCM has been developed by the V2 Organization in Rotterdam, the Netherlands. V2 "...has conducted research on the documentation aspects of the preservation of electronic art activities -- or *Capturing Unstable Media* -- an approach between archiving and preservation...defining strategies for collecting and preserving actual works is outside the scope of this research project " (13) CMCM is not intended for preservation per se, but as a conceptual model for documenting and describing art projects. Nonetheless, CMCM is a rich model with multiple potential applications and influences, preservation among them. CMCM has identified a goal of interoperability that goes beyond crosswalks (comparison and mapping). CMCM could potentially be used in combination with other models such as the one described in this paper.

CMCM recognizes the importance of collaboration and distributed authorship in media art. CMCM accommodates this by defining a list of creative roles such as choreographer and visual designer, meant to act like the semi-standardized set of roles described in film credits. These roles are assignable to almost any level of description from the entire project to individual sub-components, not through their inclusion structurally in an XML document, but via linking. CMCM has similarly detailed lists of technical behaviors, dependencies and relationships, project component types, and more.

Most of these lists embody crucial recognition of factors absent in traditional art descriptive standards, but as implementation strategies they embody the tension between sophistication and flexibility in conceptual modeling. A conceptual model for media art should allow detailed description at very granular levels, but should not necessarily require it. The level of granularity evident in CMCM points to its sophisticated grasp of the complexities of media art, but may ultimately make the model difficult to implement and test. Moreover, the defined lists of possible creator roles, user interactions, and such may be too prescriptive in the context of media art where new forms of interaction and relationships are formed at a rapid pace. Some purely technical definitions such as technical behaviors or technical component types are perhaps best defined by the technology industry. Time, expertise, and labor from the art and cultural communities are perhaps best utilized to define elements and structures unique to media art that can incorporate technical metadata, thus making the whole effort more feasible and sustainable. CMCM would benefit from clear guidelines that define high-level simple application and low-level granular usage.

CMCM includes description of certain intents and parameters in the form of user interactions. Audience interaction with media art works can be described explicitly using CMCM, but other types of intents and parameters are included only implicitly. These other parameters include choices the artist allows others to make in preserving the work or environmental variables that presenters of the work must choose between. Ideally, these other parameters would be explicit and thus durable as well.

CMCM clearly recognizes the dynamic and process-oriented nature of media art practice. V2 has developed a comprehensive and rich conceptual model that has influenced, and may indeed be used in conjunction with, the system of formal notation proposed in this paper. To aid with basic high-level interoperability, a crosswalk between CMCM and other models is included in Appendix 1.

3.3 Digital Music Library Data Model Specification V2

"The Indiana University Digital Music Library project aims to establish a digital music library testbed system containing music in a variety of formats, involving research and development in the areas of system architecture, metadata standards, component based application architecture, network services, and intellectual property rights. This system will be used as a foundation for digital library research in the areas of instruction, usability, and human-computer interaction. " (14)

Like PANIC, this model adapts existing standards in order to leverage previous efforts and increase the potential for interoperability. This data model is in part based on the Functional Requirements for Bibliographic Records (FRBR) (15). In the Digital Music model, “a single musical work can be manifested in a range of physical formats". Like FRBR, the Digital Music Library Data Model clearly separates the logical work from its various manifestations or physical expressions.

Despite the domain origin of the Digital Music Library Data Model, this model may describe a score as a component of a musical work but does not itself function as a score for re-creating the work (proper digital music score formats like MusicXML (26) are of course limited to sound and graphic notation anyway). This is not a deficiency in Music Library Data Model because like FRBR before, it is a conceptual model intended to support discovery and access more than preservation or re-creation. This model describes a musical work, focussing on aspects that support search and access. This model does not include a mechanism for explicit description of choices, intents, triggers and actions surrounding the work in a way that would allow it to act as a guide for re-creating or re-performing the work itself. Thus this model holds a slightly different position in relation to the work itself than is desired for a media art score.

4 Syntax and Expression Format for a Formal Notation System

It is no coincidence that all of the related projects surveyed above utilize XML as the syntactical expression format for their conceptual models. In addition to being widely documented and used in numerous domains and communities, XML supports two important aforementioned requirements for a formal notation system for media art.

XML is standardized in the sense that the specification is not proprietarily owned by any private interest. Thus many industry sectors and others are in an equal position to develop XML schema, tools, and technologies. An equally important aspect of the status of XML as a standard is that it is not dependent on any particular hardware or software environment. Adoption of XML endows benefits of standardization, increased interoperability and durability for preservation.

XML also meets the requirement of transparency. It offers support for high-level meaning to be included as natural language text that is human-readable with minimum interpretation or processing. At the same time, XML supports machine-readable "hooks" that aid in computer-mediated processing and use of the content. XML integrates these two levels of meaning and utility while clearly defining their boundaries. Representing both levels of meaning using simple text, XML is both transparent and robust.

XML is scaleable. It supports simple implementation that favors human-readable text with minimal automation support. XML also supports more complex implementation with increasing automation support. Complex implementation ranges from the ability to search and retrieve textual elements to incorporating a text-encoded bitstream that can be rendered into the appropriate binary format such as a digital video or interactive database. XML functionality can itself be extended with additional related standards such as Resource Description Framework (16) or OWL (17). These should be brought into a formal notation system for media art only after a solid baseline standard is established.

For the purposes of developing a formal notation system for media art, it is logical to pursue XML as a baseline expression format. It bears mentioning again that the overarching conceptual model for media art may also be expressed in other ways such as a database file, but that XML comprises the default and preferred expression format. XML can be used to both define and implement the conceptual model.

5 Survey of XML Schema Standards

XML is a standardized syntax, but it does not define what that syntax is used to construct. Domain-specific communities are left to define the structures they want to build using XML. Archivists have used XML to build documents of metadata about archival collections (electronic finding aids). The e-commerce industry has used XML to build temporary files that enable and record e-commerce transactions. Each community creates XML schemas or "flavors" of XML to suit specific content or functions. If an XML schema obtains enough consensus with a large enough community, then it becomes a de facto standard of its own. Here we will survey a few XML schemas that warrant investigation as the potential basis for a formal notation system for media art. It is preferable to adapt rather than invent an XML schema for reasons of interoperability and leveraging the efforts of entire communities. But adaptation is preferable here only if a given XML schema (and the conceptual model it represents) is closely compatible with an accurate description of media art and the needs of a media art score. This survey is not an evaluation of each XML schema against its intended purpose, but an evaluation of the potential suitability of each for creating media art scores.

5.1 Metadata Encoding and Transmission Standard (METS)

" The METS schema is a standard for encoding descriptive, administrative, and structural metadata regarding objects within a digital library, expressed using the XML schema language of the World Wide Web Consortium." (7)

METS has been developed by the library community and allows description of objects that are born-digital or are digital representations of physical objects. METS is commonly used, for example, to describe the structure and metadata associated with a digital representation of a book. Each page of the book may be scanned and stored as a page image. A METS document may then describe the title and creator of the METS document, the title and creator of the book, the logical structure of the book into chapters and pages, and the digital page images associated with each logical page. METS may describe the technical, rights, and administrative metadata associated with the entire book or with each page image.

METS is intended to describe objects that are all digital. Resources or assets are described in the 'file section' of METS. METS formally accommodates the description of physical objects as sources for digital surrogates (a kind of parent/child relationship). It is still the digital surrogate however, that is the primary target of description by METS. METS is not intended then to describe objects that are hybrid, part digital, and part physical. Hybrid objects such as certain media art works require that physical and digital objects be described at the same level in a kind of sibling relationship. In the latter case, either digital or physical object can be the primary target of description.

METS describes digital library objects independent of behaviors and systems so that the object can be ported between different computing environments. Each environment may then apply different functionality or behaviors to the digital object. Thus METS provides minimal support for mechanisms that declare procedure, actions, choices or variables, though METS does include a 'behavior section'. This section allows the inclusion of executable behaviors in the form of inline or linked code that may be used in association with the digital object. It does not allow for description of non-digital (physical or human) behavior that may be associated with an object. In short, METS describes what the digital object is more than what the object does or the variables that govern how the work could be re-created. This makes sense for the intended purpose of METS, but it also limits the suitability of METS for a formal notation system for media art.

METS is very flexible and is not prescriptive. Some XML schemas are created to build very specific kinds of documents such as electronic archival finding aids. METS allows one to build digital library objects within an abstract framework. The objects may be digital books, digital versions of archival manuscripts, or collections of images documenting various aspects of a painting (x-ray, infrared, visible spectrum, details). METS' ability to describe a digital object in granular detail and to allow for almost any kind of digital object are features which should exist in a system of formal notation.

5.2 Synchronized Multimedia Integration Language 2.0

"W3C's Synchronized Multimedia Activity has focused on the design of a new language for choreographing multimedia presentations where audio, video, text and graphics are combined in real-time. The language, the Synchronized Multimedia Integration Language (SMIL, pronounced "smile") is written as an XML application and is currently a W3C Recommendation. Simply put, it enables authors to specify what should be presented *when*, enabling them to control the precise time that a sentence is spoken and make it coincide with the display of a given image appearing on the screen." (8)

SMIL has been developed primarily to facilitate the presentation of multi-media rather than for description or preservation of media objects. However, SMIL includes some features that are informative toward building a formal notation system for media art. SMIL is able to explicitly declare interactivity, specifying conditions that affect the start or end of an action. SMIL is modular in design, allowing a community to incorporate its own discipline-based, customizable features. SMIL incorporates temporality in a flexible and robust way. For instance, SMIL allows the run-time of a media object to be determined at the time of play based on environmental variables.

SMIL allows user-activated technical or navigational choices to be declared directly in the metadata, rather than leaving those outside the SMIL document in the software. However, non-technical parameters that affect the configuration of the work, such as those that can be made by the artist or presenter at the time of exhibition, are difficult to describe structurally or explicitly in SMIL and thus remain invisible. This limits the ability of a SMIL document to act as a guide in the re-creation of a work except by example. Like METS, SMIL is intended to be used with all-digital objects, specifically two dimensional objects that are presented on a computer screen or projector. This limits SMIL's ability to describe hybrid or three dimensional objects and events.

SMIL is procedural in the same sense that HTML is procedural. Like HTML, SMIL does not specify actions at the level of code, but it does specify a level of declaration that best supports presentation and display (procedural actions) in a computing environment rather than the semantic or syntactic identification of content. If METS best describes what a digital object is, SMIL best describes what a digital object does.

5.3 MPEG-21 Digital Item Declaration

" MPEG-21 Multimedia Framework initiative that aims to enable the transparent and augmented use of multimedia resources across a wide range of networks and devices...MPEG-21 is based on two essential concepts: the definition of a fundamental unit of distribution and transaction (the Digital Item) and the concept of Users interacting with Digital Items. The Digital Items can be considered the “what” of the Multimedia Framework (e.g., a video collection, a music album) and the Users can be considered the “who” of the Multimedia Framework...The goal of MPEG-21 can thus be rephrased to: defining the technology needed to support Users to exchange, access, consume, trade and otherwise manipulate Digital Items in an efficient, transparent and interoperable way." (18)

MPEG-21 is part of the MPEG family of standards, and is itself a compilation of related specifications (or emerging standards). Here we are concerned with MPEG-21 Digital Item Declaration, "The purpose of the Digital Item Declaration (DID) specification is to describe a set of abstract terms and concepts to form a useful model for defining Digital Items. Within this model, a Digital Item is the digital representation of “a work” (18), and as such, it is the thing that is acted upon (managed, described, exchanged, collected, etc.) within the model. The goal of this model is to be as flexible and general as possible, while providing for the “hooks” that enable higher level functionality."

DID, like METS, is not prescriptive. It may be used to build many types of digital descriptions. The very open conceptual model of DID defines abstract elements (like container, item, component) that may be mapped to domain-specific meanings. Like METS and SMIL, DID is extensible and allows the inclusion of external descriptive practices. So an external standard like Dublin Core (DC) (19) could be used to include descriptive information within DID. CMCM could be incorporated to refine description of component parts or creator roles. The expression of the DID conceptual model is the Digital Item Declaration Language (DIDL) that is implemented in XML. DIDL allows external descriptions to be incorporated into DIDL documents by declaring a namespace in the DIDL document, such as XML or RDF, and them implementing the external description within a DIDL 'descriptor' element. This flexibility and descriptive extensibility is one reason the Los Alamos National Laboratory adopted DIDL as the building block for its digital library (20). DIDL includes detailed internal mechanisms for descriptive, technical and other metadata and does not require external descriptors, but this extensibility makes DIDL easier to adapt for domain specific purposes.

DIDL supports structured granular description of a work and explicit description of complex decision-tree like choices and conditions related to the work. Like SMIL, DIDL incorporates user interactions and choices explicitly and thus partially represents the work from the user or audience point of view. Early western dance notation similarly represented dance movements pictorially from the audience point of view and it turned out to be a mistake (21). Dancers had to learn by implementing the notation backward. While this situation is not exactly analogous to SMIL or DIDL, it illustrates the point that emphasizing the audience in the wrong way in notation systems can lead to difficulty in implementation from the other side of the stage or screen. Having said that, it is important to be able to formally include user choices and interactions for any model of media art, and DIDL seems to walk that tight rope with the right balance.

DIDL frames such user interaction in broader and ultimately more useful terms (for our purposes at least). In many XML schemas, description of "interactivity" assumes and supports an invisible barrier that separates creator and presenter from user and often structurally limits users to trivial navigational or selection actions. Instead of interactivity, DIDL describes choices without regard to who or what makes those choices. DIDL does not structurally differentiate between the choices made by creators from those made by presenters or audiences. This allows agency to assume the form of a smooth continuum that stretches between creator and user and suits the description of highly interactive works, distributed authorship, and even open-ended collaboratory projects and systems. Additional discussion of choices as implemented in DIDL is included below.

Like SMIL, but unlike METS or the Digital Music Library model, DIDL is supported by a large and diverse media and technology industry. This allows for a large enough economic base to ensure the development of cheap and plentiful tools and means of implementing DIDL. Despite the fact that XML is well supported, generic XML tools are not sufficient for creating content in a specific XML schema. Cultural projects using XML schema developed by the smaller, poorer library or museums communities have resorted to developing their own tools (such as those developed by PANIC or MOAC). The presence of industry support and tool development helps fulfill the formal notation system requirement for practical, cost-effective implementation.

DIDL accommodates description of both digital and physical primary assets at the same level (as components of the same work). Description of physical assets or resources is recommended by the Open Archives Information System framework for preservation and is required to accurately describe many hybrid media art works. Like other conceptual models, DID can be implemented as a heirarchical XML description or a more object-oriented description through use of DIDL references that can link and mutually include elements of description wherever they may occur.

At first glance, consideration of a media industry standard like MPEG-21/DIDL for adaptation as a media art formal notation system might seem awkward. However, the tradition of the arts (especially media arts) borrowing and adapting from applied sciences is well established. As far back as the sixteenth century, while developing the western system of musical notation, scholars adopted the visual alchemical symbols for gold and silver to represent perfect and imperfect tempus (22). The critical factor in favor of DIDL is that it is generic enough to accommodate domain-specific adaptation and extension.

If METS preserves objects that are acted upon through various behaviors contained in software, DIDL can instead preserve behaviors that are expressed through various objects like files, equipment and software. If METS best describes what an object is, and SMIL describes what the object does, DIDL defines the parameters that affect what the object is and what the object could be. In this way, DIDL can function as a language for creating scores.

Among the XML schema selected and compared here for their potential as a formal notation system format and on its own merits, DIDL meets the most requirements for a formal notation system and is the best choice to explore further.

6 Presenting the Media Art Notation System v1.0

What follows is a definition of the conceptual model and expression format that comprise the Media Art Notation System (MANS). The MANS conceptual model is not the same as the MPEG-21 DID model, but borrows from DID as well as other conceptual models. MANS is parallel enough to DID that MANS also uses the DIDL XML schema as its preferred expression format. MANS does not adopt DIDL as-is, but defines a set of usage guidelines that creates a new "flavor" of DIDL and adapts DIDL for domain-specific implementation.

MANS includes three main layers, the conceptual model, the preferred expression format for the model (the MANS implementation of DIDL XML), and specific document instances composed in the expression format (scores). Immediately following is an outline description of core concepts of the MANS conceptual model. These concepts are mapped to DIDL elements that are used to express them.

6.1 Outline Structure of Media Art Notation System

Corresponding DIDL XML elements are indicated in <BRACKETS>.

Score: *didl xml metadata document itself*
<DIDL>
Descriptor: *descriptive data about score document*
<DESCRIPTOR>
- Work: *logical media art work or project*
  <CONTAINER>
  Descriptor: *descriptive data about work or project*
  <DESCRIPTOR>
  - Version: *occurrence/state/ account of work*
    <ITEM>
    - Part(optional): *logical sub-component*
      <ITEM>
      Choice(optional): *variables affecting configuration*
      <CHOICE>
      - Resource: *physical or digital components*
        <RESOURCE>

In the MANS conceptual model, descriptors are required at the level of the Score and the Work as indicated above. However MANS and its DIDL XML expression allow descriptors to be attached to any level of description from the whole work to a specific file. In this model, variability necessary for preservation and re-creation (such as replacing dysfunctional files or objects with new ones) will most likely occur at the lower levels of Parts and Resources. However, collaboration and interaction choices may affect variability at higher levels.

6.2 Core Elements of Media Art Notation System

Following is a list of the core conceptual elements that comprise the media art notation system. Each is presented with its name, definition, and discussion. They are mapped to corresponding DIDL XML elements, and DIDL implementation guidelines. This mapping, along with usage guideline notes, defines the MANS DIDL implementation (other than the elements described here, MANS uses the rest of DIDL as-is). The MANS implementation of DIDL should result in valid DIDL XML documents. The following definitions also provide additional opportunities to discuss conceptual issues related to formally modeling media art. An example of a real media art work described, or scored, using the MANS model is included in the appendix.

Name: Score
Definition: A score is a specific document instance of the formal notation system. The formal notation system is an expression of the conceptual model.
DIDL XML Element: <DIDL>
DIDL Implementation Guideline: DIDL is the umbrella element for whole document. It contains directly within it a DIDL DECLARATION element that describes the document itself (author, date of creation, etc), but does not describe the media artwork.

Name: Work
Definition: Media artwork or project as a whole, including potentially several versions, occurrences, or accounts.
Discussion: This is the 'tombstone data' that will likely be crosswalked or exported to external systems to describe work as a whole. Similar to CMCM's "occurrence", "work" is here intended to mean the overall project, including any related activities such as talks, symposia, and other events that are not plainly documentation but activities considered part of work. The CMCM avoids the term "work" as being too connotative of traditional description of art objects. However, work is used here with the intent to claim the term and expand the definition of what an artwork can be. Unlike CMCM, work is used in this model not to describe artistic processes per se, but to describe a work as a dynamic entity, a set of intents expressed as parameters or choices and manifested as a product or occurrence.
DIDL XML Element: <CONTAINER>
DIDL Implementation Guideline: CONTAINER is the top-level element in the document to describe the artwork or project. Each Score should contain only one Work and one CONTAINER element. The CONTAINER element contains directly within it one DESCRIPTOR with formal descriptive metadata about the work as a whole (see below for guidelines for implementing formal descriptive metadata within this model). Descriptive metadata at this level should describe the aggregate work and act as a summary and compilation of relevant details that may be spelled out further down in the document. For instance, if the work contains various types of sub-components (one performed, another installed), then the Type for the work would include both terms. If

parts of the work as described below in the document were authored by different creators, then the creator for the work would include all their names.

Name: Descriptor
Definition: Any type of documentation of the work that is not a part of the work itself; for example thumbnails, video, descriptive metadata created by museum, text or notes which are not part of the work.
Discussion: Descriptors are required at the top levels of a score, and are allowed at any lower level, from describing major functional parts of the work to describing individual choices, files, objects, or even parts of files. This ability to describe aggregate or very granular parts is very important for complex multi-part works.
DIDL XML Element: <DESCRIPTOR>
DIDL Implementation Guideline: Text, images and other RESOURCES that are nested inside a DESCRIPTOR element are considered to comprise documentation of the work, but are not be pat of the work itself. Text, images and other RESOURCES that are not nested inside a DESCRIPTOR or ANNOTATION element are considered to comprise part of the work itself. DESCRIPTORS are the place to include information in the form of an external formal system, "mpeg21 frame work itself defines ways to use descriptors as a means to convey identification information, rights information, processing information, etc. But, to facilitate the provision of community-specific or application-specific information, descriptors may also be defined by third parties. In order to do so, typically, an XML schema with an associated xml namespace is created to contain elements and attributes required to address specific needs." (18) (see below for guidelines for implementing formal descriptive metadata within this model). Additional DESCRIPTORS at lower levels of the score document should be used only when the data is additional to, more granular, or different from the descriptive data included in parent elements. For instance, if there is only one creator of the work, and that creator is indicated in the top level description of the work, then there is no need to include that data with sub-component parts as well.

Name: Version
Definition: A specific instance, account, state, or occurrence of a work.
Discussion: Version is intended to serve as a flexible container for describing the work as a dynamic entity that may be represented by several incarnations over time or several differing viewpoints. Each version may be simple, including only one Part. A version may be complex, with multiple Parts describing logical sub-components of the work and so on. If there is only one version, then the collected (most recent manifestation as represented in storage) or current manifestation (if work is kept "live") should be described as a minimum requirement, but the score could also include past or even future versions. Each version may also describe an ‘account’ of the work (an instance as described by someone). There may be "real" versions that describe actual manifestations of the work, as well as "logical" versions that describe different accounts of the work or future/potential manifestations as outlined by the artist.
DIDL XML Element: <ITEM>
DIDL Implementation Guideline: the top level ITEM element in the DIDL document represents the Version. A Version is implemented as the top ITEM element to occur within the CONTAINER element. Each work must contain at least one version. Each

Version should be accompanied by a DESCRIPTOR that indicates the nature of the version (state, account, instance, or other form).

Name: Part
Definition: A logical sub-component of a version of the work.
Discussion: Parts should be thought of functionally rather than tangibly or physically. A tangible or physical asset in a work such as a chair or a computer file is instead described as a Resource (see below). A work that included a maze would describe the maze as a Part, and the physical panels that made up the maze as Resources within that Part. A work that included a robotic controller as a part might also include one computer server as a tangible Resource within that part, but by defining the robotic controller as a logical Part, one allows the one computer server to be replaced in a future version of the work with two servers for instance. Parts defined as logical, functional units of the work allow the integrity of the structure of the work to be maintained while allowing the variability that supports preservation. The ability to describe sub-components of a work allows descriptive granularity that is useful in many ways. For instance, it allows more precise identification of creators of different parts within a collaborative work; it allows specific designation of intellectual property rights to specific images; and it allows each part to include technical or preservation metadata that may not apply to the whole work. Media art is often a complex compilation that requires the description and differentiation between sub-component parts. Parts comprise a work, but are not independent entities themselves. Parts include not only files, physical objects, or collections of objects, but may also indicate events, places, activities, performers, etc.
DIDL XML Element: <ITEM>
DIDL Implementation Guideline: Part is expressed using the same DIDL element as Version. The two are differentiated by their position in the document. The top level ITEM indicates a Version within a score. A Part is indicated by an ITEM element contained directly within another ITEM element. Parts are infinitely nestable (DIDL ITEMS may occur within ITEMS to any level of granularity).

Name: Resource
Definition: Discrete, fixed, or tangible expression of a Part of a work.
Discussion: Resource serves as the "atomic unit" of the model; the building block of works. DIDL includes a FRAGMENT element for referencing portions of a Resource (such as a clip from a video), but whereas Resources are necessary building blocks for Works, FRAGMENTS are not required to build Resources. A Resource may be a digital file or stream or a physical object. It is recommended, but not required, that each Resource be accompanied by a Descriptor that indicates the broad preservation approach for that Resource such as Emulation or Storage (see recommended list or approaches and terms in Appendix 3). Preservation approaches should be indicated at this level of description because it is applied at this level. For instance a work that included a QuickTime movie file and a physical prop like a table might opt to Migrate the digital movie, but Store the table. It would not be accurate to describe the whole work as being Migrated or Stored. A Resource may be stored outside the score itself (as in the case of physical objects and some digital files and streams). However, digital resources may also be stored internally in the score document. DIDL allows for bitstreams to be stored inline or referenced via REFERENCES that point internally or to

other DIDL documents. Bitstreams stored within a DIDL score should be encoded as Base64. This capability raises the question of how much granularity is needed to adequately score a work of media art. It is expected that most early scores will include links and references to objects or files stored outside the score. However, implementers are advised to keep an eye toward the future as well. An XML standard that may be useful in this context is Bitstream Description Language (BSDL) (23). BSDL is not intended to describe complex, multi-part logical works like the current model, but is intended to describe individual bitstreams. BSDL is intended to adapt digital content to a variety of devices, but it does not make the content of the file format-independent. So, a presentation system would still need to be alerted to the file format that the bitstream comprises (such as a JPEG image) and be able to render a JPEG image. In the future, approaches like BSDL might allow more flexible use and on-demand variability of digital files that would be useful in this context. BSDL could also serve as a metadata description of a bitstream stored internally in a DIDL RESOURCE as a point of comparison or authentication against file bitstreams stored outside the score document.
DIDL XML Element: <RESOURCE>
DIDL Implementation Guideline: Text, images and other RESOURCES that are nested inside a DESCRIPTOR element are considered to comprise documentation of the work, but are not be pat of the work itself. Text, images and other RESOURCES that are not nested inside a DESCRIPTOR or ANNOTATION element are considered to comprise part of the work itself. Use the URI attribute of the DIDL RESOURCE element to indicate the appropriate MIME type if applicable.

Name: Choice
Definition: A choice describes a set of related selections that can affect the configuration of a work or part of a work.
Discussion: In the MANS model Choices indicate variables that come into play when the work is presented or engaged. These variables affect the configuration of the work or parts of the work. Choices describe a list of selections or variables, an agent who is authorized to make or change the choice, the amount of flexibility in implementing the selection, and choices usually indicate an initial or default selection that will be deployed if the authorized agent does not make a different selection. Initial or default selections for choices would be established when the score is originally created, preferably in consultation with the artist. Authorized agents may then make different selections each time the work is manifested or engaged. Following is a recommended list of agents who may be authorized to make or change a Choice:

artist	= most restrictive
contributor/agent	= very restrictive
host/owner	= restrictive
presenter	= open
public	= most open

Most models for media art separate choices into two categories with different structural means of implementation; choices of intent or configuration made by the artist and choices of interaction or participation made by users or audiences. However, MANS proposes that structurally consistent means of implementing choices allows a continuum of agency that goes from artist to audience. This open model of choice-making allows the creation or description of highly interactive works in which any level of choice (ranging from navigation to configuration to co-authoring) may be allowed by any type of designated agent. This continuum of agency is hinted at in CMCM's “interaction level” indicating the intensity of an interaction and by implication the level of agency. One primary reason for choosing DIDL XML as the expression format for the MANS conceptual model is this ability to define high and low impact choices that accurately represent the range of media art works. Choices as implemented in this model allow the explicit description of variables in presenting or interacting with media art works. Moreover, Choices allow this model to be used as basis for systems that support open or collaborative artist communities like the Pool (5). Users may need works to be highly configurable for a variety of reasons including simply negotiating technical configuration such as network stream speed, resolution, and file format for viewing works online. Choices may be made by people or automated by software.

Choices and selections should be explicit in the score document and it should not be presumed that there exists some external "master" document that explains each Choice. For instance, if only chosen selections and not all possible selections were included in the score document, than the choices themselves become implicit, requiring a greater deal of inference upon re-creating or re-performing the work. Choices often define a limited range of parameters within which the artist will allow future change. DIDL defines a mechanism for declaring Choices, and MANS presents an example set of choices and selections (see Appendix 5). MANS allows for locally defined Choices to be included in some scores as needed to accurately describe specific works. The principles behind this recommendation are that each score should be robust, holographic, and meaningful even when used out of context, each score should make explicit as many important aspects of the work as possible, and MANS should allow flexibility in local implementation.

DIDL XML Element: <CHOICE>

DIDL Implementation Guideline: Choices apply to the Work or Part of a Work that directly encloses them in the DIDL XML. There is no limit to how many choices may be included in one score, for one work, or for any part of a work. Initial or default selections/answers to Choices are recorded in the DEFAULT attribute of the DIDL XML Choice element. Some Choices may be repeated throughout the score document and one may want to minimize repetition by declaring a choice once and thereafter referencing it via the DIDL XML REFERENCE element. However, not all authoring or presentation software may be able to easily resolve REFERENCES.

Name: Condition

Definition: The consequence of a choice that that makes other Choices, Parts, or Resources optional.

Discussion: A Condition makes the enclosing element optional, based on the outcome of a choice. So, entire portions of the work, or just the configuration of specific files, can be conditional on Choices made by the authorized agent. Conditions may link together related or interdependent choices and allow the construction of complex decision trees that can approximate compound Boolean if/and/or/else/then statements.

DIDL XML Element: <CONDITION>

DIDL Implementation Guideline: Not all Choices must have a corresponding Condition, nor must each Condition have a corresponding action. However, Conditions are most useful in linking together a string of interdependent Choices into a decision tree or in establishing the inclusion or configuration of a Part or Resource.

Name: Annotation
Definition: Notes or commentary that are not part of the work or part of the official Score.
Discussion: Unlike Descriptors, Annotations are comments that are not part of the work and do not necessarily become part of the score document either. Annotation may be used to enable a discussion around a score or work as might occur in a collaborative community project or online discussion forum. Annotations may become part of the score, or may be held outside.
DIDL XML Element: <ANNOTATION>
DIDL Implementation Guideline: Annotation should be used sparingly, only when needed as a device to keep descriptors that are part of score separate from those that will not (such as temporary discussions). By default, use Descriptors instead.

6.3 Implementing Descriptive Metadata in the Media Art Notation System

In some XML schemas and related conceptual models, descriptive metadata is considered the core of the record. With MANS however, descriptive metadata is not considered core, because the wall label or "tombstone data" that comprises descriptive metadata in most traditional art contexts may not provide the most useful description of media art works. For instance, complex multi-component works, highly collaborative works with numerous authors over time, works that re-configure over time, or works with complex media descriptions are not well accommodated in traditional descriptive systems. In "Death by Wall Label" (24), Jon Ippolito writes, "Wall labels are the pins that fix the butterflies of new media to museum walls." In MANS, rather than serving as the "core" of the record or score, descriptive metadata is considered a metaphorical "Applications Programming Interface" or way to plug MANS descriptive practice and scores into more traditionally oriented museum or library descriptive practices, standards, and systems. Descriptive metadata within MANS is of course necessary at some level, and it ensures a minimal level of interoperability with other descriptive standards and systems.

The DIDL XML model allows external descriptive standards to be incorporated into DIDL XML documents by embedding them into a DIDL DESCRIPTOR element. MANS adapts and extends the Dublin Core (DC) (19) standard as the standardized, structured, formal expression of descriptive metadata within a Score. The DC was developed by cultural agencies with input from industry. DC was developed to describe digital documents, but has been applied and adapted to describe art objects and other cultural artifacts. DC defines a minimal set of fifteen descriptive elements that balances utility with tractability (it is interesting to note that the earliest western musical notation started off with fifteen elements/notes (22)). DC serves as a kind of golden rule, and many other cultural informatics standards map to DC, thus ensuring interoperability of DC structured descriptive metadata. It has been noted in CMCM and other places that DC is too simple to serve as the basis for an overall conceptual model for media art. DC declares only descriptive metadata but not administrative, structural, technical metadata or other information contained, for instance, in DIDL Choices. DC does not accommodate the various levels of detail or complex meshwork of distributed authorship indicated by most media art works. However, if used appropriately within a larger model as in MANS, DC can offer a fitting means for incorporating descriptive metadata and ensuring a certain level of interoperability with many other models and standards. DC as applied in MANS is required at the top levels where it describes the Score document, and the Work as a whole, but it may also be used to describe sub-component Parts of a Work. In a departure from traditional art description, all of the elements below are repeatable in any given record.

6.3.1 MANS Descriptive Metadata Elements

Name: Type
Definition: Genre or classification of a Work or Part of a Work
Discussion: See appendix for recommended list of genre types for media art works based on functions and behaviors rather than physical characteristics. A Work or Part may be described by multiple Type terms.
DIDL XML Element/DC Element: <dc:type>

Name: Date
Definition: Date of first creation or occurrence of a Work or Part. If muliple dates are listed, then the first should be the date of creation. Other dates could be important milestones in the life of the Work that are spelled out in the DIDL XML structure.
DIDL XML Element/DC Element: <dc:date>

Name: Title
Definition: A name given to a Work or Part. First instance of which is the primary title. Others may include alternate or past titles.
DIDL XML Element/DC Element: <dc:title>

Name: Measurements
Definition: Dimension, duration, file size, or other measurement applied to the Work or Part
DIDL XML Element/DC Element: <dc:format.extent>

Name: Subject
Definition: That which is depicted in the Work or Part, or important concepts, places, people, or things associated with work that may serve as intellectual access points. Keywords.
DIDL XML Element/DC Element: <dc:subject>

Name: Creator
Definition: An entity or entities primarily responsible for making the Work.
Discussion: Creators may be artists, organizations, etc. In "Death by Wall Label", Jon Ippolito argues against relying on misleading group identifiers and suggest including all known personal names as well.
DIDL XML Element/DC Element: <dc:creator>

Name: Contributor
Definition: An entity or entities responsible for making contributions to the content of the Work or who are secondarily responsible for making the Work.
DIDL XML Element/DC Element: <dc:contributor>

Name: Host
Definition: Owner or steward of the Work. The permanent owner of the Work should not to be confused with temporary presenters of the Work. Being duplicable, digital art may be collected by multiple owners. Unlike traditional art descriptive schemas, MANS allows the identification of multiple owners of the work.
DIDL XML Element/DC Element: <dc:publisher>

Name: Identification
Definition: An unambiguous reference to the Work within a given context.
DIDL XML Element/DC Element: <dc:identification.number>

Name: Version
Definition: Identification of an instance or occurrence of the Work
Discussion: Similar to the meaning of the core MANS concept, Version. However, in that larger context, Version indicates an instance of the Work which is then described in terms of structure, Choices, etc. In this context of descriptive metadata Version is used more simply to identify the version in question with a numerical or other system. In a description of a whole Work, this Version would be used to identify all the versions that are described in that Score. Upon presentation of a Work, this Version would be used to indicate which specific Version was being shown. Version may include minimal provenance information that relates to development and transition between versions. For instance, Version could be used to add text that might appear on a wall label, indicating that the current version was "an interpretation of" or "based on" another version of the Work.
DIDL XML Element/DC Element: <dc:relation.version>

Name: Language
Definition: A natural language of the intellectual content of the resource
Discussion: Language here should be used to describe only natural human languages associated with the Work. Artificial languages such as computer programming languages are indicated elsewhere as technical metadata.
DIDL XML Element/DC Element: <dc:language>

Name: Location
Definition: The current physical or logical location of the Work or Part.
Discussion: Where the Work or Part is stored. Location indicators may be in the form of URLs, CD or other fixed media identification, file structure (logical), shelf (physical), or other form as appropriate.
DIDL XML Element/DC Element: <dc:identification.location>

Name: Authorization
Definition: Statement about authority to re-create, configure (make Choices), access, verify, represent, depict, or otherwise use Work or Part
Discussion: Authorization may include, but is not limited to, intellectual property rights information. Authorization may be used to create a link to a more detailed policy governing use of the Work, such as a Creative Commons license (25). Authorization may also be used to link to mechanisms for verifying authenticity of the Work such as watermarks or checksums for digital Parts. Authorization should not be overused, as the

MPEG-21 development group is currently developing a new detailed specification for declaring and verifying rights.
DIDL XML Element/DC Element: <dc:rights>

There are a few DC elements that have been adapted above for the current purpose, while others have been omitted. Following is an explanation of why three elements in particular were omitted. The DC FORMAT element would seem a natural candidate to include for description of technical/media objects because it describes "the physical or digital manifestation of the resource". However, even seemingly simple media works usually contain multiple, sometimes dozens, of digital and physical formats. Such a list quickly becomes an unwieldy inventory of the Work, rather than the simple indicator intended by DC. Moreover, the DC inspired descriptive metadata in the MANS model is again not intended to act as a core or comprehensive record of the work. Technical metadata of the type that could be squeezed into DC FORMAT is better incorporated in the description of the Work through other DIDL XML mechanisms such as DIDL RESOURCE. However, if a media work is technically very simple, FORMAT may optionally be included in the descriptive metadata. The DC RELATION element would also seem a natural candidate for complex media works. However, structural information about the relationship between the various versions and parts of a Work are better handled by the MANS conceptual model and DIDL XML schema outlined above than by attempting to compress such information into one element here. The DC DESCRIPTION element is similarly omitted in favor of the DIDL DESCRIPTOR element that serves the same purpose and is better integrated into the DIDL XML schema (in fact, all the DC-like descriptive metadata outlined above would be contained within a DIDL DESCRIPTOR element in a Score).

Appendix 1 includes a crosswalk of the descriptive metadata elements listed here with those in the Dublin Core and other art-oriented descriptive standards. An example of how such descriptive metadata is implemented in a Score is included in the MANS example in the Appendix 4.

7 Conclusion

The Media Art Notation System has three levels of implementation progressing from simple to more complex. These levels qualitatively change the nature and function of the resulting Score. The first and simplest level of implementation would be a short, simple Score that is mainly comprised of high-level descriptive metadata and minimal DIDL XML markup. This level would create a Score that serves as a record of the Work. The second level of implementation would include more granular description of sub-component parts expressed structurally through DIDL XML markup and more Descriptors containing images and other media that document the Work. This would create a machine-processable Score that functions as a representation of the Work. The third level of implementation would include technical metadata, Choices that model every behavior of the Work, very granular description and structural markup to the level of individual Resources, and inline bitstreams or linked source files that comprise the work itself. This would create a machine-processable Score that would function as a working model or manifestation of the Work (or partial manifestation for hybrid physical/digital Works).

A Media Art Notation System allows one to grow into the future embodied by the third level of implementation. However, a more realistic scenario is that Scores created in the near future using MANS would serve as non-automated guides for humans to re-create or re-perform a work for an exhibition. These scores might not include inline bitstreams that could be interpreted by emulators or such, but they could easily include links from Resource descriptions to original files and streams. In this way the MANS Score would represent a media-independent logical backbone for the Work that relies on the original files to provide the detailed functionality and appearance. This near-term and feasible level of implementation would create an interoperable record of the work, a guide to re-creation, and a way to maintain the integrity and cohesion of complex Works.

MANS is one of a hand-full of proposed conceptual models and expression formats that could be used to describe, investigate, and utilize media art. It remains to artists, museums, and others who make up the cultural informatics community to critique, refine, integrate, and test such models. It is the hope of this author that MANS will make a unique contribution to the field, aid practical but urgent activities like preservation, and allow deep, rigorous investigation into the nature of media and art. It is clear that in these efforts there is no one clear silver-jacketed-bullet solution. Reflecting the fragmentary, dynamic nature of media art works themselves, solutions will come in the form of interpenetrating clouds of conceptual models, multi-layered implementations, argument and collaboration.

Biography

Richard Rinehart is a practicing digital artist and Director of Digital Media at the Berkeley Art Museum/Pacific Film Archive. Richard has taught digital media art at UC Berkeley and San Francisco Art Institute. Richard sits on the Executive Committee of the UC Berkeley Center for New Media and on the Board of Directors for New Langton Arts. Richard is project manager for "Archiving the Avant Garde: Documenting and Preserving Digital / Media Art". Richard may be reached at rinehart@berkeley.edu or http://www.coyoteyip.com.

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Notes

(1) Archiving the Avant Garde,
    http://www.bampfa.berkeley.edu/ciao/avant_garde.html
(2) Variable Media Network,
    http://www.variablemedia.net
(3) Open Archives Information System,
    http://ssdoo.gsfc.nasa.gov/nost/isoas/
(4) Extensible Markup Language,
    http://www.w3.org/XML/
(5) Pool, University of Maine,
    http://river.asap.um.maine.edu/~jon/pool/splash.html
(6) "Implementing Preservation Strategies for Complex Multimedia Objects",
    Choudhury, Sharmin; Hunter, Jane
    http://metadata.net/newmedia/Papers/ECDL2003_paper.pdf
(7) Metadata Encoding and Transmission Standard,
    http://www.loc.gov/mets
(8) Synchronized Multimedia Integration Language,
    http://www.w3.org/AudioVideo/
(9) Base64 Encoding,
    http://www.w3.org/2000/09/xmldsig#base64
(10) "Reality and Chimeras in the Preservation of Electronic Records", Bearman, David,
    http://www.dlib.org/dlib/april99/bearman/04bearman.html
(11) MOAC, Digital Asset Management Database,
    http://www.bampfa.berkeley.edu/moac/damd/DAMD_manual.pdf
(12) Encoded Archival Description,
    http://www.loc.gov/ead

(13) Capturing Unstable Media,
http://www.v2.nl/Projects/capturing/
(14) "Digital Music Library Data Model Specification V2",
http://www.dml.indiana.edu/pdf/DML-DataModel-V2.pdf
(15) Functional Requirements for Bibliographic Records,
http://www.ifla.org/VII/s13/frbr/frbr.pdf
(16) Resource Description Framework,
http://www.w3.org/RDF/
(17) OWL Web Ontology Language,
http://www.w3.org/TR/owl-features/
(18) MPEG-21 Overview v.5,
http://www.chiariglione.org/mpeg/standards/mpeg-21/mpeg-21.htm
(19) Dublin Core,
http://www.dublincore.org
(20) "Using MPEG-21 DIDL to Represent Complex Digital Objects in the Los Alamos National Laboratory Digital Library", Bekaert, Jeroen, et al
http://www.dlib.org/dlib/november03/bekaert/11bekaert.html
(21) "History of Notation", Ballet Magazine, Victoria Watts
http://www.ballet.co.uk/mar98/notation_history.htm
(22) " The History and Evolution of the Musical Symbol", Scelta, Gabriella F.
http://www.intelligirldesign.com/literature/musicsymbol.pdf
(23) " Bitstream Syntax Description Language: Application of XML-Schema to Multimedia Content Adaptation", Amielh, Myriam; Devillers, Sylvain,
http://www2002.org/CDROM/alternate/334/
(24) " Death by Wall Label", Ippolito, Jon [publication forthcoming]
(25) Creative Commons,
http://www.creativecommons.org
(26) MusicXML
http://www.musicxml.org/xml/musicxml-tutorial.pdf

Appendices

Appendices are included in a separate document.