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Interactive multimedia on CD-ROM: experiments with risk assessment

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Abstract

In this paper, the author discusses collection and item level assessments of CD-ROMs, including advocating the viewing of works in their "native" environment to assist with maintaining the integrity of the original work. Strategies for grouping titles that have similar preservation needs are discussed, in order to develop appropriate preservation workflows. The paper summarizes lessons learned through the examination of multimedia titles held in the Avery Fisher Center for Music and Media (AFC) in the Elmer Holmes Bobst Library at New York University (NYU) as part of the Moving Image Archiving and Preservation Program (MIAP). `

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Introduction

Multimedia is now so much a part of our lives that it is difficult to imagine a time without streaming media and high-end graphics on our computer screens, or immediate access to information from around the world. US students entering college in 2008 will not have experienced life without desktop and laptop computers, the Internet, and the World Wide Web in their schools, libraries or homes. Computers from the 1990s now look clunky and inelegant; early multimedia works look simple, lacking in detail, design, and complexity. Older interfaces, once mysterious, may now seem obvious or trite. In a society used to speedy transmissions and constant upgrades, we may have little patience for the slow pacing of early multimedia.

At the time of this writing, the US Congress is considering new support for the preservation of orphaned motion pictures and recorded sound. As custodians of audiovisual materials, we have learned to appreciate early film and television despite what we may perceive as its artifice, uneven production values or outdated themes. We consult scholars, historians and users for their input during selection, examining the works for their value as information, evidence and artifacts.

Multimedia collections in libraries trace histories of hypertext and hypermedia – what Anne Granny Francis calls "multimodal" works, employing "writing, visuals, sound, movement, spatiality".[1] Without the direct experience of these works – being able to see, hear, and interact with them – how can re-construct and understand this unique period of technological development and visual culture in the late 20th century?

Libraries could take steps to discard early multimedia as they did their film libraries, looking upon them as old media dependent on obsolete or little-used systems, and having no place in centers serving current users. (In fact, some of the film collections discarded by libraries were saved by collectors and archives, and are now being mined for rare titles and for elements necessary to re-construct and preserve damaged prints.)

As "new media" ages, we increasing see journal articles and full-length works addressing the history and meaning of multimedia both on our library shelves and in our libraries' electronic resources.[2] Film and media studies departments are increasing incorporating curriculum on newer forms of media production, and educators and students are seeking out early examples of multimedia for study in the arts, humanities and social sciences. Libraries often hold art works by early experimenters with computer art, electronic fiction and audio art, particularly in the period prior to and during the first decade of the Web.

The library community is now well aware of the fragility and ephemerality of digital works, and has been alerted to the difficulties with preserving work that has the additional component of behaviors.[3] However, few resources exist that describe practical strategies for risk assessment of multimedia works, except on a conceptual level. Several articles by Deborah Woodyard on surveying and migration of digital works at the National Library of Australia have been the most helpful.[4] Woodyard describes in detail a

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[1] Anne Granny-Francis, *Multimedia: Texts and Contexts* (London, Thousand Oaks CA and Delhi: Sage Publications, 2005), 2.

[2] In addition to original scholarship, several anthologies have re-publish writings from media and computer "pioneers". Examples include: Noel Wardrip-Fruin and Nick Monfort (ed.), *New Media Reader* (Cambridge MA: MIT Press, 2003); and Randall Packer and Ken Jordan, *Multimedia: from Wagner to virtual reality* (New York: Norton, 2001). The New Media Reader includes a CD-ROM with video clips, games, web sites and other media, which suffers from its own dependencies.

[3] Howard Besser was among the first to alert the library community to the special needs of complex media works, especially art works. See: Howard Besser, "Digital Longevity" in *Handbook for Digital Projects: A Management Tool for Preservation and Access*, ed. Maxine Sitts (Andover MA: Northeast Document Conservation Center, 2000), 155-166; and Howard Besser, "Longevity of Electronic Art". 2001. Accessed 5/12/08 at http://www.gseis.ucla.edu/~howard/Papers/elect-art-longevity.html

[4] See: Deborah Woodyard, "Physical format electronic publications in the National Library of Australia: report on a preservation survey" in the Staff Papers section of the web site of the National Library of Australia, 1997. Accessed 5/10/08 at http://www.nla.gov.au/nla/staffpaper/cwebb6.html; and Deborah Woodyard, "Farewell my Floppy: a

process of migrating floppy disks to CD-R with mixed results, as some of the works (particularly the Macintosh-based works) were not functional after the migration.

In this paper, we will look at collection and item level assessments, based on the principle that delving deeply into the dependencies inherent to the works is the only way to ensure their continued use as complete works. Investigations reveal that there sets of works that will not benefit from migration, and instead must be emulated. In addition, I will advocate viewing works in their "native" environment; that is, as close as possible to the system requirements for the work when it was released, particularly for artist works, where 'look and feel', timing and other factors are critical.

The paper also offers somewhat of a laundry list of lessons learned through the examination of multimedia titles held in the Avery Fisher Center for Music and Media (AFC) in the Elmer Holmes Bobst Library at New York University (NYU). While the primary focus is on CD-ROMs, AFC groups works that exist on floppy disk, CD-ROM or DVD-ROM together into a collection. The materials are given a local Call Number beginning with prefix XMM.

The paper reflects research both by the author and by students in the Moving Image Archiving and Preservation Program (MIAP) at NYU.[5] The paper should be considered a work-in-progress, as the investigations are ongoing, and while the author is well versed in computers, she is not a computer scientist or information technology specialist, so corrections are welcome. Also, since some of the research takes place within the context of a university program, future progress can be expected to be slow but steady unless major research funds are found.

This paper makes general observations about multimedia optimized for either a Microsoft Windows-based platform (referred to as "PCs"), a Macintosh platform or both. However, most of the works given greater attention were made for the Macintosh or 'Mac', and as is explained below, the earliest published works in the AFC collection require Macs to run. Also, MIAP began setting up an "Old Media Lab" in Spring 2008 that will eventually be cross-platform; however, we started out installing Macintosh systems, and PCs will follow.

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strategy for migration of digital information" in the Staff Papers section of the web site of the National Library of Australia, 1997. Accessed 5/10/08 at http://www.nla.gov.au/nla/staffpaper/valadw.html

[5] MIAP is part of the Cinema Studies Department in the Tisch School of the Arts at New York University. Students examined interactive multimedia in the course "Handling New Media" taught by the author. See acknowledgements at the end of the paper. Papers by students that examine individual CD-ROM titles can be found under that course title in the MIAP Digital Archive at http://www.nyu.edu/tisch/preservation/program/student_work/.

Early multimedia – production elements and dependencies

Briefly discussing high points in computer history[6] during the late 1980s and early 1990s – the period surrounding the earliest titles in the AFC collection – is a reminder of how valuable an understanding of production processes are to preservation efforts. Identifying the characteristics of computer-based works and charting their dependencies are activities that can go as deep as a researcher has the time and interest to pursue.

Platforms and operating systems

Desktop computers were available in the early 1980s, but Apple, Inc. made history with its first Macintosh in 1984, offering a graphical user interface, an image creation and editing program, and a mouse as an input device.[7] Early Macs were based on the 68000 series chip, which was the building block of all Macs until the PowerPC (PPC) was introduced in 1994.[8] Early Macintosh computers ran OS 6 or earlier systems; OS 7 was introduced in 1991, and OS 8 in 1997.[9]

While there were earlier IBM and IBM-compatible computers to use graphical displays and a mouse, in 1990, the release of the Microsoft 3.0 operating system was an important development, offering 16-bit color. The introduction of the Pentium microprocessor followed in 1993.[10] The Pentium became the standard for PCs, and its increased processing power allowed for better graphics and sound capabilities. The first graphical user interface for the PC, Windows 95, was introduced in 1995, followed by Windows 98 in 1998 and in its second edition in 1999.

Changes in operating systems and processors – such as Apple's recent introduction of the Intel chip – mark shifts in the way the platforms behave and handle legacy software and data. Production software, playback software or browsers – they are all tied to certain operating systems and hardware. Software can run natively, through emulation (as in Mac's OS Classic emulating OS 9 in OS X), or other processes. Every multimedia work will have its own set of requirements, but will run more or less well in environments that diverge from the recommended or optimized systems. Problems can be difficult to diagnose; here are a few examples:

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[6] The Computer History Museum has is a very useful online exhibition for getting generally oriented to 20th century computer history through 1994, and has been used as a basis for the information in this section of the paper, if not otherwise cited. Please see: Computer History Museum, "Timeline of Computer History", 2006. Accessed 5/12/08 at http://www.computerhistory.org/timeline/.

[7] A personal favorite, the Commodore Amiga introduced in 1985 and had powerful graphics using only 1 or 2 MB of RAM. Unfortunately it never gained in a significant market share. Amiga systems were used heavily by artists, and their products probably exist only in personal collections and ad hoc archives, making them even more at risk and problematic than those produced on Macs and PCs.

[8] The Apple Museum, "1990 to 1999: Decline and the i-Revolution" in the History section of The Apple Museum web site, 1998-2008. Accessed 5/12/08 at http://www.theapplemuseum.com/index.php?id=57.

[9] Miwa Yokoyama, "Apple Computer Timeline, 1990s to Present", unpublished paper, 2008; and Leah Churner, "Apple Timeline 1995-1990", unpublished paper, 2008. These papers will be published on the web in August 2008 (see MIAP student timeline below).

[10] Information on PCs and Windows was taken from the Computer History Museum cited above, and Microsoft Corporation, "Windows Products and Technology History", 2008. Accessed 5/9/08 at http://www.microsoft.com/windows/WinHistoryIntro.mspx

- Faster processors can speed up videos that did not have a fixed frame rate as part of the programming, affecting the timing of works.
- Elements of the desktop suddenly can be visible (such as the dock used in MacOS X) over the designed screen of the work.
- Older works may include fonts and/or system files that need installation but are not appropriate to current system software, or more difficult to install than with past operating systems.

Software

While CD-ROMs can be produced with and dependent upon any number of applications, the development of authoring software was key to the proliferation of early multimedia works. Marc Canter, developer of the first commercial multimedia authoring system in 1984, defines the software as being comprised of "…a powerful, easy-to-use notational system that will unify entire multimedia systems in one score, just as an orchestra is unified by the symphonic score used by its conductor. Their scores will be capable of representing any sort of data, including the action codes necessary for the interactive programming (or authoring)." In the late 1980s, Canter's company Macromind released early versions of a program later renamed Macromedia Director that was widely used and is still available today.[11]

In 1993, HyperCard was developed at Apple, Inc. Built on the concept of "stacks" of cards or pages, the program allowed for interlinking of information contained on windows within the computer screen and was able to be customized through the scripting language HyperTalk. Initially the cards included just text; later sound and images were added, and finally video.[12] Apple discontinued HyperCard as a program in the early 1990s, despite outcry from the user community.[13] HyperCard players were shipped with at least some of the Apple G3 models, which were introduced in 1999 and were capable of natively running MacOS 9.[14]

Consulting how-to books from the 1990s can be a good source of information on early authoring software and other applications that are part of CD-ROM publishing.[15] SuperCard, a program much like HyperCard, was utilized during the 1990s and is still available,[16] and will run on MacOS10.4 or later, an operating system still very much in use. The extent of backward compatibility on SuperCard is unknown.

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[11] Marc Canter, "The New Workstation: CD-ROM Authoring Systems" in *Multimedia: from Wagner to virtual reality*, Randall Packer and Ken Jordan (ed.) (New York: Norton, 2001), 179-188. See also: Adobe Systems Incorporated, "Macromedia: The Story", 2008. Accessed 5/10/08 at http://www.adobe.com/macromediastory/.

[12] One of the titles held by AFC is a multimedia work on how to make and use multimedia with HyperCard. It was distributed on 3 ½" floppy disks for the Mac, and produced by Cornell University. See: Louise Holmes and Cornell Information Technologies, Learning Technologies Program, Version 1.0 (Santa Barbara CA: Intellimation, 1993). AFC local Call Number is XMM 27.

[13] International HyperCard User Group (iHUG), n.d. Accessed 5/14/08 at http://www.ihug.org/

[14] Apple, Inc., "Power Macintosh G3 Desktop and Minitower: CD Contents" in the Support section of the Apple, Inc. web site, 2008. Accessed 5/13/08 at http://docs.info.apple.com/article.html?artnum=24282

[15] See: Ted Vaughn, "Multimedia Authoring Tools" in *Multimedia: Making It Work, Second Edition* (Berkeley: Osbourne McGraw Hill, 1994), 147-188.

[16] Solutions Etcetera, Super Card: Powerful, Easy! 2008. Accessed 5/13/08 at http://supercard.us/

In addition, the software Storyspace, produced by Eastgate, Inc., should be noted as software utilized by those involved in writing hypertext, before and after color and graphical user interfaces were common. The Electronic Literature Foundation has raised awareness of the need for preservationists to attend to works created in Storyspace in the larger context of migrating works of electronic literature.[17]

After a work is authored, it is output to be viewable through a player, usually a player specific to the production software. Generally speaking, the software and players are proprietary and are backward compatible only to a limited degree. Examples of other players from various years are Macromind Player, Flash Player, Shockwave, Real Player, and Windows Media Player.

It is important to note that QuickTime as a production and delivery software for video was introduced in 1991 for the Mac and bundled with MacOS 7.1 in 1992. However it was in 1994 with QuickTime 2.0 that full screen video was first possible. QuickTime was also delivered for Windows in 1994, and in 1996 was Web-enabled.

Lastly, a definitive moment for hypermedia came in 1993, when MOSAIC, the first graphical web browser was developed, at the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign. MOSAIC was available for Mac and Windows platforms by 1994, and the introduction of Netscape followed the same year.

CD-ROMs, even when authored, can have numerous dependencies through software. Take for example, the 1993 publication by Warner New Media, "How Computers Work." The CD-ROM appears to run on custom software and needs QuickDraw, QuickTime, Simple Text, Teach Text; the CD-ROM also demos FileMaker Pro, Microsoft Word and Excel.

CD-ROM as storage and delivery media

SONY Corporation was the first company to market 3 ½" floppy disks and drives in 1981. The CD-ROM was developed and promoted by Philips and SONY in 1984, and the first commercially produced CD-ROM-based databases were published in 1985. *Bibliofile* was a database of catalog records for libraries, and Grolier's released an electronic encyclopedia.[18] At the end of 1991, three million CD-ROMs were in use worldwide, and commercially produced CD-ROMs productions had exceeded 3,000 titles.[19]

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[17] Alan Lui, et al, "Born Again Bits: A Framework for Migrating Electronic Literature", Version 1.1, August 5, 2005. Accessed 5/14/08 at http://eliterature.org/pad/bab.html#reimplement. See also: Kara Van Malssen, "Risk Assessment and Structure of an Interactive CDROM", 2005. Accessed 5/16/08 at http://www.nyu.edu/tisch/preservation/program/student_work/index-public.shtml.

[18] Nicholls, Paul, "CD-ROM Publishing" in *Multimedia: A Management Perspective*, Antone F. Alber, (ed.) (Belmont CA: Wadsworth Publishing Company, 1996), 242. While the date of publication is 1996, the article appears to have been written in 1994.

[19] Ted Vaughn, *Multimedia: Making It Work, Second Edition* (Berkeley: Osbourne McGraw Hill, 1994), 460.

The CD-ROM market continued to grow, and despite the birth of the web, in 1994 CD-ROM was still seen as "one of the most attractive and economical information storage and publishing media available today", particularly valuable for its ability to organize and deliver information stored in databases.[20] With bandwidth and processing power still undeveloped, the future of CD-ROM seemed to be the answer to many problems.

> "One CD-ROM provides durable removable random access to the equivalent of 2,000 floppy disks (61.7 pounds), 360,000 pages of paper (3,780 pounds), 100 four drawer file cabinets, 1,600 microfiche films (14 pounds), 13 standard 9-track tapes, or 26,000 scanned images at 300 dpi. To download the contents of a single CD-ROM would take 736 hours at 2400 baud or 186 hours at 9600 baud (Douma, 1992). These are impressive statistics, and suggest many archival, corporate, and commercial applications, dramatically reduced postage costs, and tremendous cost savings over traditional media such as paper and microform, as well as an alternative to the expensive online medium.[21]"

While the increased storage capacity of DVD-ROM has been a factor in making it a popular storage medium, CD-ROMs are still widely in use. AFC records show that the highest number of CD-ROMs purchased annually were in the years 2000, 2005, and 2003 respectively.

The principle of examining works in their native environment

Conservation and preservation principles whether for analog and digital materials, call for the "preservation of the aesthetic, conceptual, and physical characteristics of the cultural property", taking into consideration actions that compensate for loss.[22] However, without examining a work in its native environment, how can one have a benchmark against which to compare these characteristics? Without knowledge of the original work, how can one determine if it has undergone significant change when brought forward into new systems?

Changes in look and feel, timing, linking, and behaviors are examples of aspects of the work that may change when works are opened in a computer environment unlike the one for which the work was optimized. Also, playback in a native environment offers the best opportunity to evaluate a work for completeness, if parts of the work are missing through loss of functionality when using "upgraded" systems. Several examples of changes in look and feel and timing have already been noted above. Others include errors associated with unsupported software, resulting in dropout of those sections, or problems with image or sound quality.

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[20] Nicholls, Paul, "CD-ROM Publishing" in *Multimedia: A Management Perspective*, Antone F. Alber, (ed.) (Belmont CA: Wadsworth Publishing Company, 1996), 242.
[21] Ibid., 242. Nicholls cites Douma, B. Canadian Guide to Optical Publishing. 1992. Ottawa: OPTIM Corporation.
[22] American Institute for Conservation of Historic and Artistic Works. *AIC Code of Ethics and Guidelines for Practice*, 1994. Accessed 5/16/08 at http://aic.stanford.edu/about/coredocs/coe/index.html.

Attention to set up of a computer for playback of legacy CD-ROMs is very important and can mitigate some problems (such as by setting screen resolution and color characteristics that correspond to original system requirements for the work). Without proper set up, to the inexperienced eye, a work can appear non-functional or damaged beyond repair. For example, inadequate RAM on the computer can cause severe playback problems, which may be incorrectly attributed to problems with the work itself.

One could argue that CD-ROM producers knew and accepted certain changes in display and/or timing, given differences in platforms, computer configurations and with later works, network speeds. There is no question that for some works, a particular look and feel could be interpreted as being less important, especially if a work is meant for, or is functional on, one or more platforms.[23] However speculations about producer intent are difficult to gauge.

As noted above, MIAP is establishing an Old Media Lab, concentrating this year on Mac computers. (Next year we intend to develop PC capability in the Lab, from Windows 3.1 to the current operating system.) The immediate goal was to make available working computers representing Mac hardware from series 68000 chips to the new Intel-based machines, and operating systems from system 6 to the current OS, Leopard.

Additional goals were for the computers to have enough RAM, to eliminate the potential of RAM-related problems (which may be misinterpreted) and to have appropriate displays and a wide range of peripheral devices. While we have made excellent progress toward the goals, outfitting an early Mac with an external CD-ROM has proved challenging. However, we have up till now been making minimal purchases, rather outfitting in-house legacy systems and utilizing spare parts. In retrospect, a more strategic plan is recommended to build the best possible machines.

MIAP is also in the process of collecting production and player software – such as all QuickTime and HyperCard players – as well as browsers. The software is archived as well as installed on the legacy machines. After this process is complete, emulators will be archived and installed where needed. This process, while time-consuming, will give MIAP great flexibility to continue research on the effects of changing computer systems on the integrity of CD-ROM works. Interestingly, CD-ROMs can be a source of older player software, as it was practice in the early years to include players on the disk with the content.

Apple, Inc, makes older software is available for some, but not all Mac computers, but its site for legacy software has not been updated since 2001.[24] Apple define vintage products as “those that were discontinued more than five and less than seven years ago”, and provides service only as provided by California (US) laws; all others are defined as

[23] For an analysis of the effect of playback on PC and Mac platforms, see Kara Van Malssen, “Risk Assessment and Structure of an Interactive CDROM”, 2005. Accessed 5/16/08 at http://www.nyu.edu/tisch/preservation/program/student_work/index-public.shtml.

[24] Apple, Inc. “Older Software Downloads” in the Support section of the Apple, Inc. web site. 2001. Accessed 5/12/08 at http://www.info.apple.com/support/oldersoftwarelist.html

obsolete and not service is provided.[25] The company does have specifications for older systems in their Support section, but they can very difficult to locate.[26]

Methodologies for systematic testing of single works in multiple computer environments are still under development. Strategies will be discussed below.

Overview of the multimedia collection in the AFC

The AFC multimedia collection is largely CD-ROMs, although the catalog lists nineteen titles on 3 ½" floppy disks and one title on a 5 ¼" floppy disk, Also, there are a small number of titles on DVD-ROM.[27] The overwhelming majority of titles, an estimated 295 in a total of 319 titles, are on CD-ROM. In some cases, the titles contain multiple types of media. For example, a HyperCard-based CD-ROM may trigger a laser disk or DVD-ROM, or a title may include information on videotape, DVD-ROM, CD-ROM and in print.

The 5 ¼" disk is no longer available; however, most if not all, of the 3 ½" disks are installed on a Mac running system MacOS 8 and are available to users.[28] AFC also maintains one Mac running MacOS 9, one running MacOS X, and one PC (operating system unknown).

Publication dates for the titles span from 1990-2008. (The 2008 title is a DVD-ROM.) A little more than half of the titles (estimated at 165) have publication dates of 1999 or earlier. While a thorough assessment of the collection has not been completed, titles with publication dates between 1990 and 1996 have been analyzed more completely.

Issues with collection level assessment of multimedia

A picture of the status of a collection and its risks is gained from examining patterns emerging from data on factors such as format, age, physical condition, and availability for replacement. While the physical condition of the CD-ROMs is an important for preservation planning, condition has have not addressed in any significant way thus far.[29] However, in 2006, MIAP students created a CD-ROM inspection sheet, which was used as a guide for their assessments of individual titles. In addition, issues of copyright and ownership have largely been unexplored, but it is recognized that these issues will have a

[25] Apple, Inc., "Vintage and obsolete products" in the Support section of the Apple, Inc. web site, 2008. Accessed 5/12/08 at http://support.apple.com/kb/HT1752?viewlocale=en_US.
[26] For current systems back to 1997, see: Apple, Inc., "Specifications" in the Support section of the Apple, Inc. web site, 2008. Accessed 5/12/08 at http://support.apple.com/kb/HT1752?viewlocale=en_US. For older systems, see: Apple, Inc., "AppleSpec pre November 1997" in the Support section of the Apple, Inc. web site, 2008. Accessed 5/12/08 at http://www.info.apple.com/support/applespec.legacy/index.html.
[27] Numbers reflected in this paper are titles, not disks. A full count of actual disks was not possible for this version of the paper; however a single title can contain one piece of media, or in one case, 155 CD-ROMs. DVD-Video titles are given a different local Call Number.
[28] Conversation with Don Trammel, Supervisor of AFC Media Services, Spring 2005.
[29] IFLA makes available its own CD-ROM covering this subject: UNESCO, *Safeguarding our Documentary Heritage*. Accessed 5/15/08 at (http://www.ifla.org/VI/6/dswmedia/en/index.html.

strong effect on decision-making regarding maintenance and preservation of the AFC collection.

Starting with the oldest media makes sense for a number of reasons – older media is more subject to physical deterioration and wear – but also based on the assumption that older systems are more difficult to find and keep functional. Drawing on the Bobst library catalog for data, we are only able to analyze works by publication date, as neither "record dates" nor acquisition dates are available.

One could expect, or perhaps hope, that a library's catalog would provide useful information with which to analyze a collection of multimedia. However, we found that the existing metadata is only marginally useful in selection, risk assessment and preservation planning. The Bobst library catalog, designed for intellectual access, is weak on technical metadata and is also not designed to capture metadata needed for long term care of the works.[30]

In early XMM records, catalogers appear to be looking for the proper place for technical details, first entering the information in the 538 field, and then settling on the 500 field with the label "Technical Details". Before data entry for the format field was standardized, a multimedia work might be described as "computer data and programs". Even with recent entries, the format field could be identical for CD-ROMs and DVD-ROMs, as both are the same size.

Knowing that technical specifications are essential to risk assessment of these works, it would be logical to analyze the Technical Details fields. However, out of an estimated 109 XMM titles with publication dates between 1990 and 1996, there are no technical specifications in the AFC catalog for 39% (42) of the titles.

With the remaining 61% of titles, some useful information can be gained. Of the 109 titles from 1990-1996, only 9% (10) of the titles will play on the Windows platform, and 4% (4) titles are meant for both Macs and PCs. Nearly 50% of the titles are known to be dependent on a Mac platform. Further analysis of the Technical Details could result in groups of CD-ROMs categorized by operating systems and other software dependencies.

These system requirements are relatively straightforward:

> Macintosh computer with 2 MB of RAM; hard drive with 4 MB free; system 6.0.5 or higher; HyperCard 2.0 or higher; headphones or external speakers.

However, these requirements appear more problematic:

> Apple Macintosh with MIDI interface; Opcode max; Common Lisp; Smalltalk; Think C; hard drive; CD player.

[30] This problem is not confined to surveying multimedia collections. See Paula De Stefano and Mona Jimenez, "Commercial Video Collections: A Preservation Survey of the Avery Fisher Center Collection at NYU", in *The Moving Image* no. 2 (2007): 55.

In some cases, the Technical Details list require multimedia players, but for the most part, information on players is lacking. For AFC titles published between 1990-1996, only 8% (9 titles) listed the player HyperCard as a system requirement in the Technical Details. (The specifications represent only 4 distributors.) From later research at the item level, it was found that no less than 50% (54 titles and counting) of the early titles are dependent on HyperCard for viewing.

Distributor information can also be helpful, particularly if one has familiarity with their products. As mentioned earlier, Eastgate, Inc. is the company that developed Storyspace, and all of their products, especially if published around the same date, could have similar dependencies. Unfortunately in other cases, the fact that several products are published by the same company does not imply a shared technical structure.

Research at AFC has led me to suspect that there are several other broad categories of CD-ROM works that could have similar characteristics and could respond to similar strategies. As web browsers became more available in the late 1990s, in some cases content was organized using offline web sites (or the work would include a combination of offline and online components.) Thus, these works no doubt require specific browsers, may be missing content if links are broken, and are subject to other risks for browser-based works, such as deprecated tags.

Works that have external dependencies or are used to control external devices may be another category of works. HyperCard was in some cases used to control laser disk players. Also, certain CD-ROMs may simply be storage media for text or image documents, without an interface. Some CD-ROM works at AFC require Adobe Acrobat Reader (an application for reading PDF files.) These disks may simply contain directories of files, with very little or no design.

So while metadata from the catalog record is limited, it can reveal some helpful information, in terms of establishing broad technical categories. A second step in collection level assessment might be to browse print materials associated with the works, which can be found in the CD-ROM case itself or in separate documents. These materials may be more explicit on technical issues, both for identification of software and players, and for trouble-shooting when item level assessment begins.

In 2008, MIAP students produced a timeline of computer characteristics that is intended to be an aid to preservationists who are attempting to determine technical requirements, particularly to replicate the disk's native environment. For example, if a CD-ROM published in 1993 lacks Technical Details, one could consult the timeline on Windows and Mac hardware and operating systems that were in use at that time. (The timeline will be published by August 2008 on MIAP's web site, linked off the Research section.[31] We look forward to user feedback.) Although comparing a work's date of publication with computers introduced close to that date can give a clue to the work's technical needs, this approach is not ideal.

[31] See http://www.nyu.edu/tisch/preservation/research/.

In most cases, a collection level assessment is inadequate to create a true picture of the needs of a multimedia collection. A preservation plan must be developed through a deeper articulation of the risks, gathered by research at the item level. Only by putting a CD-ROM in an actual machine can additional the information be obtained.

Issues with item level assessment

Item level assessment can take several forms, and requires a flexible approach, as one inevitably comes up against roadblocks with older titles. As mentioned above, having several computers representing different processors and operating systems can allow one to match as closely as possible the viewing environment recommended by the producer.

The primary goal of item level assessment is to verify and/or further identify categories of items with shared hardware and software dependencies. Workflows for further research and for preservation actions are then possible. Standard workflows may be possible, for example, for all works dependent on a Mac with the Macromind player (an early version of Macromedia Director). However, some works will be impossible to categorize and will require a specialized response.

For example, through a collection level assessment, one may have been able to sort the majority of a given collection by platform dependence, and then by production and/or player applications. As CD-ROMs are viewed and examined, additional works may be found with the exact same dependencies. A workflow could then be developed for all of the works.

As mentioned above, the first step is to run the work in a computer environment that meets stated system requirements. Instructions and "ReadMe" files should be sought out and followed for set up. For those familiar with legacy multimedia, several quick checks can be done to try and determine software dependencies. Directories can be scanned to find applications. On the Mac, checking metadata under "Kind" in the directories can offer clues, as well checking icons for files, which may be recognizable. "Get Info" for a file will also often help identify an application and its version.

It is also likely software exists that could automate this task, with a tool like DROID. Developed by the United Kingdom's National Archives, DROID is "designed to meet the fundamental requirement of any digital repository to be able to identify the precise format of all stored digital objects, and to link that identification to a central registry of technical information about that format and its dependencies."[32]

Unfortunately, directories and files are not always visible. Macromedia Director files, for example, may be hidden so the user only sees the icon from which the work is launched. Other programmers have simply designed the work so that only the icon is visible. Colin Holgate, a programmer who worked on CD-ROM projects for the Voyager Company, suggests using the software TinkerTool to reveal hidden files.[33]

[32] National Archives, *DROID*, 2006. Accessed 5/17/08 at http://droid.sourceforge.net/wiki/index.php/Introduction.
[33] Colin Holgate, presentation in MIAP class "Handling New Media, February 14, 2008.

A similar, but more serious obstacle from a preservation perspective, is that authored projects can be locked, meaning that they cannot be opened in the production software within which they were designed. This precludes the migration strategy of opening the projects in its production software and re-saving it in a more recent version, making emulation the only option.

The depth of an item level assessment will depend on the resources available to the library, both human and technical. After the development of more refined categories of risk through the item level assessment, prioritization can be done, enabling a detailed workflow for migration to be developed, and the actual migration to be undertaken.

Strategies for moving forward

Our research at MIAP has not yet progressed to the point of undertaking a migration project. However, a number of strategies and recommendations have emerged through our research.

Where production software is still in use (such as with Macromedia Director), the "master" should be migrated through current software, as long as the compromises to a work's aesthetic, conceptual and physical characteristics are too great. Several stages in migration may be needed, if the software is not sufficiently backward compatible. For example, a work made in Director 4 will not open in the current version, intermediate migrations are required.

Migration workflows should be developed for certain categories of work; however, it should be recognized that emulation or re-construction are likely the only alternatives for certain works: Macintosh works produced prior to the introduction of the Intel chip;[34] works where it is not possible to migrate within production software; and works where the compromises to a work's aesthetic, conceptual and physical characteristics are too great. (Research on PC-dependent titles is needed.)

There is a need to establish oral histories collections to document CD-ROM production from various points of view, among them the remembrances of publishers, artists, project managers, designers, programmers, and software developers. A tremendous amount was learned from Holgate's presentation to the MIAP class. (The presentation has been transcribed and will be posted in MIAP's research site.) Archives of manuals, software and other documentation also needs to be established, or if they exist, to be promoted.

Open source interpreters, where possible, need to be developed to "unlock" multimedia works. The Electronic Literature Foundation proposed this strategy.[35] Persons better versed in programming need to be consulted about the feasibility of this proposal.

[34] Intel-based MacIntosh computers consistently have difficulty displaying early CD-ROM works, even though the Macs have been designed to handle some backward compatibility.
[35] Alan Lui, et al, "Born Again Bits: A Framework for Migrating Electronic Literature", Version 1.1, August 5, 2005. Accessed 5/14/08 at http://eliterature.org/pad/bab.html#reimplement.

Commercial solutions must be studied. Solutions Etcetera, the developer of SuperCard, advertises for the migration of HyperCard stacks, saying its scripting language is "over 80% compatible with Hypertalk".[36] Areas of incompatibility are significant; for example, the use of external commands and functions that may affect playback of QuickTime files, color, and palette controls.[37] Testing will reveal if the compromises are acceptable in a conservation/preservation context.

Strategies need to be developed for documentation, including structural mapping of multimedia works, to address dependencies internal to the works (key linking and actions), to be used to locate files when trouble-shooting, and to stand in for the works as archival documentation when the actual works are no longer viable.

Research collaborations between museum conservators, digital library staff, audiovisual preservation experts, archivists, library conservators, multimedia producers/artists and other stakeholders need to be undertaken. For examples, time-based media art conservators are doing deep analysis of individual multimedia art works, and need to solve the same storage and retrieval issues being tackled by digital library staff; however these persons do not necessarily cross paths professionally.

User groups, computer scientists and enthusiasts must become our partners. For example, groups such as the International HyperCard Users Group or iHUG, may be helpful partners, although it is difficult to tell from their web site if they are still active.[38] Another group that is still posting is HyperCard: Discussion group for HyperCard, a Yahoo group.[39]

Concerning selection and preservation management

Selection for preservation based on long-term research, curricular and/or archival value is often done after a process of overall collection assessment is completed. The advantage of conducting selection first is that resources, in this case primarily human resources, will not be wasted on materials that are in distribution and can be replaced, or lack value according to experts. The process of assessing interactive multimedia is a complicated one, and not to be wasted on works that cannot or should not be preserved. Consideration of value and significance, availability for replacement, and best copy research are all topics not explored in this paper but ones that must be part of a process of prioritization for preservation.

Finally, we must consider who should and will take responsibility for multimedia works. Centers such as AFC are most concerned with delivering content to current users in the most latest and most efficient technological format. Facing a space crunch and the reality

[36] Solutions Etcetera. "Welcome HyperCard Users" on the web site SuperCard: Powerful, Easy! 2008. Accessed 5/13/08 at http://supercard.us/HyperCard/index.html
[37] Solutions Etcetera. "What is Unsupported?" on the web site SuperCard: Powerful, Easy! 2008. Accessed 5/13/08 at http://supercard.us/HyperCard/index.html
[38] International HyperCard User Group (iHUG), n.d. Accessed 5/14/08 at http://www.ihug.org/
[39] "HyperCard: Discussion group for HyperCard" on the web site of Yahoo! Finance Groups. 2008. Accessed 5/14/08 at http://finance.groups.yahoo.com/group/HyperCard/. Colin Holgate is a recent contributor to the group.

that few users ask for older CD-ROM titles, AFC will be putting a portion of the collection of interactive multimedia into off-site storage. Fundamental questions arise. Is a circulating library, with its mission of making accessible reference copies of audiovisual and computer works, equipped to take on the long-term preservation of these multimedia titles? Should the collection be assessed not only for its value to current users, but also for its archival value? Should a library transfer these works an archive with an appropriate collection policy?

Investigations into risk assessment for interactive multimedia will much helpful information applicable to other "born-digital" works that are rife with actions and behaviors, to ensure the works are incorporated into planning and implementation of emerging digital repositories. We welcome discussion of further practical approaches that can be undertaken by library and archive staff to tackle these complex and intriguing works.

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