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Distant Music: Delivering Audio over the Internet

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NOTE: At the time of publication, author Richard Griscom was affiliated with the University of Illlinois at Urbana-Champaign. In June 2004, he joined the staff of the University Library at the University of Pennsylvania.

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Abstract
Advances in audio technology in the 1980s and 1990s made it possible for librarians to create digital copies of sound recordings and to provide off-site access to them through streaming-media servers. Because streaming technology could accommodate heavy use at odd hours from any location, librarians quickly applied the new digital audio technologies to curricular listening assignments, providing a parallel to the print "e-reserves" projects developed by academic libraries during the 1990s. The results of a survey of thirty-nine digital audio reserves projects offers information on streaming formats, streaming rates, access control, user interfaces, staffing, equipment, and costs.

Keywords
digital audio, streaming audio

Comments
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DISTANT MUSIC: DELIVERING AUDIO OVER THE INTERNET

By Richard Griscom

During the past two decades, the capacity of the personal computer to capture, store, deliver, and play sound has revolutionized audio services in libraries. The computer audio technology of the 1980s allowed librarians to begin transferring sound from deteriorating or obsolete media to more stable formats, and more recently, advances in network speed, audio compression, and streaming technology have offered libraries opportunities to extend access to their sound recording collections in ways that were barely imaginable a decade ago. Users are now able to listen to recordings remotely, they can listen at different points of the same recording simultaneously, and they have easy access to recordings that were once restricted because of their condition or format.

In describing these new collections of digitized sound, music librarians have used a number of terms, the most common of which is "digital music library," a natural extension of "digital library," widely used to describe digitization projects in libraries. The libraries comprising the Digital Library Federation have arrived at the following definition of "digital libraries":

> Organizations that provide the resources, including the specialized staff, to select, structure, offer intellectual access to, interpret, distribute, preserve the integrity of, and ensure the persistence over time of collections of digital works so that they are readily and economically available for use by a defined community or set of communities.[1]

In 2000, Amanda Maple and Tona Henderson described the issues that must be confronted by a librarian planning a digital music library project, and explained the decisions made for their own project at Pennsylvania State University.[2] The issues fall into three broad categories:

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1. Daniel Greenstein, "DLF Draft Strategy and Business Plan," Public Version 2.0, 25 September 2000, http://www.clir.org/about/strategic.htm (accessed 27 November 2002).

2. Amanda Maple and Tona Henderson, "Prelude to a Digital Music Library at the Pennsylvania State University: Networking Audio for Academic Library Users," *Library Resources & Technical Services* 44 (2000): 190–95.

infrastructure (including the selection of hardware, software, streaming technology, and method of access); collections (including decisions on what to digitize and why, and related questions of copyright); and staffing (including who does what, who employs them, how the work is funded, and who provides training and public service).

In 1999, when Maple and Henderson wrote their article, no more than fifteen libraries were digitizing audio, but since then, dozens of libraries have mounted digitization projects, and the number continues to grow. Now that a substantial base of digital music library projects is in place, we can assess how librarians have dealt with the issues identified by Maple and Henderson. In order to collect information on the projects, I distributed a note on MLA-L[3] on 10 January 2002 asking librarians engaged in digital audio projects to participate in a survey. I sent questionnaires to the fifty respondents, and thirty-five were completed and returned. In preparation for the present article, I sent a note to these initial thirty-five respondents in July 2002 asking for updated information. At the same time, I issued a second call on MLA-L and received eight more responses, yielding a total of forty-three responses. The respondents represent forty-two libraries: thirty-seven university libraries and five college libraries (see table 1).

PRESERVATION AND ACCESS

The principal work of the projects undertaken by these forty-two libraries falls into two broad categories: reformatting rare recordings or recordings in obsolete formats, and making high-demand recordings more easily available to the public—in other words, projects that provide preservation and access, activities that have been closely linked during the past two decades.

Historically, preservation and access have been seen in opposition: materials are preserved by restricting access to them, and in turn, providing access to materials endangers their preservation. During the last quarter of the twentieth century, initiatives to reformat materials—by transferring the sound from a wax cylinder to reel-to-reel tape, for example—allowed librarians to preserve materials by shifting access away from the original to a surrogate. The process of reformatting achieves the goals of both access and preservation, and they become reciprocal activities. Rather than standing in opposition, one supports the other. Paula De Stefano, who outlines this history in a recent set of essays on preservation, observes

3. The Music Library Association electronic mailing list, mla-l@listserv.indiana.edu. Archives are available at http://listserv.indiana.edu/archives/mla-l.html (accessed 27 November 2002).

TABLE 1. Institutions participating in the survey

Appalachian State University	Rutgers University
Auburn University	Trinity College
Brandeis University	Tufts University
Brigham Young University	University at Buffalo
Brown University	University of California, Berkeley
California Institute of the Arts	University of California, San Diego
Cornell University	University of California, Santa Barbara
Emory University	University of Cincinnati
Grinnell College	University of Hartford
Harvard University	University of Illinois at Urbana–Champaign
Haverford College	University of Missouri–Kansas City
Indiana University Archives of Traditional Music	University of Nebraska
Indiana University Music Library	University of Rochester
James Madison University	University of South Carolina
Louisiana State University	University of Virginia
Middlebury College	University of Washington
New York University	University of Wisconsin–Madison
Northwestern University	Vanderbilt University
Pennsylvania State University	Washington State University
Princeton University	Washington University
Rice University	Wellesley College

that "Preservation and access share a correlative relationship: One directly implies the other. They also share a causal relationship: The need for access to an item triggers the need to preserve it, just as the preservation of an item provides continued access."[4]

De Stefano notes that libraries embarked on microfilming projects in the 1980s primarily to preserve materials; although increased access was a recognized benefit, it held only secondary importance. (The same could be said of contemporaneous sound preservation projects using tape as a preservation medium.) De Stefano argues that with the introduction of digitization, the driving force behind reformatting is now access rather than preservation, and in fact the distinction between the two has become blurred:

> Today, with the emergence of electronic information, access has become even more consequential. Without electronic access to machine-readable information, for all practical purposes, the information might as well not exist. It is at this point that the relationship between preservation and access

4. Paula De Stefano, "Digitization," in *Preservation: Issues and Planning,* ed. Paul N. Banks and Roberta Pilette (Chicago: American Library Association, 2000), 319.

> becomes more than reciprocal—it becomes almost synonymous. In the digital world, access supersedes preservation.[5]

In the realm of print materials, the benefits that digitization offers to access are unquestioned, but preservationists continue to debate the value of digitization as a method for long-term preservation. The principal concern is that the digital files themselves pose short-term preservation problems. According to Janet Gertz, director of preservation at Columbia University,

> To date no one can prove that any digital version will survive and still be accessible beyond a few decades, despite much talk about migration and emulation, especially considering the repeated intervention these will require. . . . Lacking agreed-upon mechanisms for this assurance, and lacking longevity, digital copies alone cannot constitute preservation.[6]

The proposed solution to the longevity problem articulated by Gertz and others has been to take a "hybrid" approach to preservation—maintain traditional methods of preservation, and digitize only for the benefit of access: "For now, the desired goal must be to exploit the access capabilities of digital technology and combine them with the longevity of proven preservation methods."[7]

For print materials, the proven preservation method continues to be a transfer of the image to microfilm, so a combination of microfilming and scanning comfortably meets the goals of both preservation and access. For sound recordings, however, such a simple solution does not exist. A hybrid approach is not possible because the traditional medium for sound recording preservation, reel-to-reel tape, does not meet the requirements of long-term preservation. Tape is reliable for one or two decades compared to at least five hundred years for microfilm.[8]

In fact, some sound preservationists now argue that the media used to store digital sound are more reliable than magnetic tape. Samuel Brylawski, head of the Recorded Sound Section at the Library of Congress, recently argued that

> [d]igital media have the advantage of not suffering any loss of information as they are copied, unlike the generational losses inherent in the duplication of

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5. De Stefano, 320.

6. Janet Gertz, "Selection for Preservation in the Digital Age: An Overview," *Library Resources & Technical Services* 44 (2000): 97.

7. De Stefano, 314. This hybrid approach was first presented by Don Willis in *A Hybrid Systems Approach to Preservation of Printed Materials* (Washington, D.C.: Commission on Preservation and Access, 1992).

8. *Preservation Microfilming: A Guide for Librarians and Archivists,* 2d ed., Lisa L. Fox, ed. (Chicago: American Library Association, 1996), 18.

> analog media such as discs and cassette tape. The future of audio preservation is reformatting audio tapes and discs to computer files and systematically managing those files in a repository.[9]

At the December 2000 conference Folk Heritage Collections in Crisis, Elizabeth Cohen argued that the digitization of sound recordings cannot be postponed until the technology has matured: "to delay the transfer of analog media into the digital domain until it has reached perfection and reliability is to compromise preservation. The more time that passes, the more we allow the further degradation of analog materials."[10] For sound recording preservationists, digitization does not simply provide the luxury of easy access; it has become the preservation method of choice as libraries and archives race to reformat older materials before they deteriorate beyond the point of use.

Digital Audio Preservation Projects

The earliest reported digital audio project—at the University of California, San Diego, begun in the mid-1980s—applied computer audio technologies to the preservation of sound recordings. The number of libraries engaged in digital audio preservation projects has grown steadily through the years. Fourteen (exactly one third) of the forty-two libraries represented by the survey report that they currently digitize audio as a means of preservation. The recordings being preserved fall into a number of categories: noncommercial historical recordings, local concert and recital tapes, rare 78s, and field recordings on wax cylinders are a few examples.

Often the work involves more than simply creating a high-fidelity copy of the original recording. New technologies have made it possible to "clean" the sound of recordings by filtering extraneous noise—the clicks and pops of 78-rpm recordings, for example—with minimal loss of musical content. Typically, a preservation master is made of the original recording and the filtering is applied to service copies destined for public listening. Once the sound has been captured, it can be stored on a variety of media: recordable CD-ROMs (CD-Rs), tape, and hard drives are the most common.

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9. Samuel Brylawski, "Preservation of Digitally Recorded Sound," in *Building a National Strategy for Preservation: Issues in Digital Media Archiving* (Washington, D.C.: Council on Library and Information Resources; Library of Congress, 2002), 61. Also available electronically at http://www.clir.org/pubs/reports/pub106/pub106.pdf (accessed 27 November 2002).

10. Elizabeth Cohen, "Preservation of Audio," in *Folk Heritage Collections in Crisis* (Washington, D.C.: Council on Library and Information Resources, 2001), 21. Also available electronically at http://www.clir.org/pubs/reports/pub96/preservation.html (accessed 27 November 2002).

One respondent mentioned that her library digitizes "materials in problematic formats (open reel, 78 rpm)," explaining that "these are converted to permit easier access to [the] material. This might be a subset of preservation, but from my vantage, we prioritize our preservation [digitization] according to vulnerability. We digitize not particularly vulnerable materials to make them easier to use." The librarian's comment reinforces De Stefano's observation that with digitization, the distinction between preservation and access has become blurred. While librarians might have embarked on their audio digitization projects as a means of preservation, we see examples where the goal is to provide access to materials that are awkward to use, and preservation is seen as only a by-product.

THE NETWORK DELIVERY OF SOUND

This blending of preservation and access in digital audio projects was made possible through advances in computer audio and network technology. Prior to the 1990s, the technology did not offer librarians what they needed to deliver sound to users through networks. The audio technology itself was limiting: users had to download an entire sound file before listening to any part of it; the raw sound files[11] were extraordinarily large and costly to store (when judged by standards of the time); and the speed of a typical dial-up connection was not sufficient to make downloading such large files practical. Downloading a five-minute uncompressed sound file, for example, would take at least five hours using a 28.8 kilobits-per-second (kbps) modem, the standard dial-up speed in the mid-1990s.[12]

Several advances in technology during the 1990s made the network delivery of sound feasible: during the course of the decade, network and dial-up transmission speeds increased; audio compression technology made it possible to reduce the size of audio files (though with a corresponding deterioration in fidelity); and audio streaming technology became commonplace with the release of Progressive Networks's RealAudio in April 1995.[13]

11. Pulse Code Modulation (PCM) data, typically stored as WAV, AIFF, or Compact Disc Audio files.

12. At 28.8 kbps, one megabyte of data would take between six and twelve minutes to download; therefore, even under optimal conditions, no more than ten megabytes of data could be transferred in one hour. When converting compact disc audio to a raw WAV file, one second of 16-bit 44.1 kHz stereo sound yields approximately 175 kilobytes of data, so a five-minute work would produce a 52.5 megabyte file requiring at least five hours to download.

13. At the same time, Indiana University was developing its own proprietary streaming technology for use with its Variations Project, which was put into production in April 1996. See David E. Fenske and Jon W. Dunn, "The VARIATIONS Project at Indiana University's Music Library," *D-Lib Magazine,* June 1996, http://www.dlib.org/dlib/june96/variations/06fenske.html (accessed 27 November 2002).

Audio compression takes a raw sound file and reduces its size by eliminating redundant and other presumably nonessential parts of the audio signal—for example, frequencies that are outside the range of human hearing. An encoding program determines, through the use of algorithms, exactly which parts of the signal should be removed. By eliminating data, the size of a sound file can be reduced considerably. MP3, the most popular compression algorithm, shrinks the size of a file to approximately one tenth of the original.[14] Other compression formats include RealAudio, QuickTime, Shockwave, LiquidAudio, Advanced Audio Coding, and Windows Media Audio.

Even after compression, a sound file remains fairly large, which is where streaming technology comes into play. A streaming server delivers the sound file in a series of small pieces, sent over the network at a rate that allows them to arrive in the listener's computer and sit in a small buffer until needed. After they have been played back, they are discarded to make room for more pieces of the sound file. By maintaining this controlled stream of data, the server can deliver large sound files to the listener quickly and efficiently and eliminate the need to wait for the completion of a long download before listening can begin.

DIGITAL AUDIO RESERVES PROJECTS

One third of the libraries responding to the survey have been digitizing audio as a means of preserving sound recordings, and some of these projects have been in production for nearly two decades. The vast majority of libraries, however, have begun their digital audio projects relatively recently, and they are using streaming technology to enhance access to traditional collections of commercial recordings, specifically to the recordings placed on reserve for classes. Thirty-nine (93 percent) of the forty-two libraries are providing streaming audio for reserve listening (see fig. 1).

The focus on reserves should come as no surprise. Reserve recordings constitute a relatively small, well-defined collection that is heavily used, with sharp spikes in use around exam time. Streaming technology allows libraries to provide around-the-clock reserve listening to students both on campus and off, so students usually can listen whenever and wherever they want. Digital audio reserves give the students a good reason to love

14. MP3, officially known as MPEG-1, Audio Layer III, is an audio subset of the 1992 MPEG-1 standard developed by the Motion Picture Experts Group, a working group of the International Standards Organization. MP3-encoded files served as the foundation for popular file-sharing services such as Napster and Audiogalaxy, which provoked aggressive legal action from the recording industry during the first few years of the twenty-first century.

their library, and librarians love not seeing them in long lines at the reserve desk the night before freshman music history exams. Maple and Henderson commented that students at Pennsylvania State University appreciate "the off-campus access and use the service at all hours of the day and (especially) night."[15] Exit-gate counts inevitably decline, but service improves, and as a result more students listen.

Even when access to digital audio reserves has been restricted to the library building, use of reserves has increased. Statistics kept at Indiana University during the first three years of the Variations Project showed that use of digital audio reserves, which can be accessed only within the library, increased as each month passed, while use of reserves in traditional formats declined significantly; use was heavy during exam periods (over four thousand player launches per day during exam weeks); and users were listening to far more titles than they had using traditional formats.[16]

Because most of the reported digital music library projects have been limited to reserve listening, I will devote most of the remainder of this article to a summary of the decisions the thirty-nine institutions have made in developing their digital audio reserves services. The questionnaire sent to the participants consisted of thirty-two questions, covering most of the issues raised by Maple and Henderson, grouped under the same three broad categories of infrastructure, collections, and staffing. Maple and Henderson mentioned that underlying all three areas are questions of funding, and the questionnaire included a few questions addressing start-up and ongoing costs.

Infrastructure

Streaming Technology

The choice of streaming audio format is central to a networked audio reserves project since it determines—and sometimes is determined by—the choice of software and hardware for the project.[17] Unless a music library has the technical expertise to strike out on its own, the driving

15. Maple and Henderson, 195.

16. Jon W. Dunn and Constance A. Mayer, "VARIATIONS: A Digital Music Library System at Indiana University," in *Digital Libraries 99: The Fourth ACM Conference on Digital Libraries, August 11–14, 1999, Berkeley, CA* (New York: Association for Computing Machinery, 1999), 16. Also available online at http://www.music.indiana.edu/variations/VARIATIONS-DL99.pdf (accessed 27 November 2002). Mary Wallace Davidson, head of the Cook Music Library at Indiana University, reports that use has doubled since Dunn and Mayer's article was published. In 2002, player launches during exam weeks numbered about eight thousand per day (e-mail from Davidson to the author, 3 October 2002).

17. Many of the most popular audio formats are proprietary, and the corporations holding the rights to a format may control software support for their format, which means that use of the format often is restricted to specific operating systems and hardware.

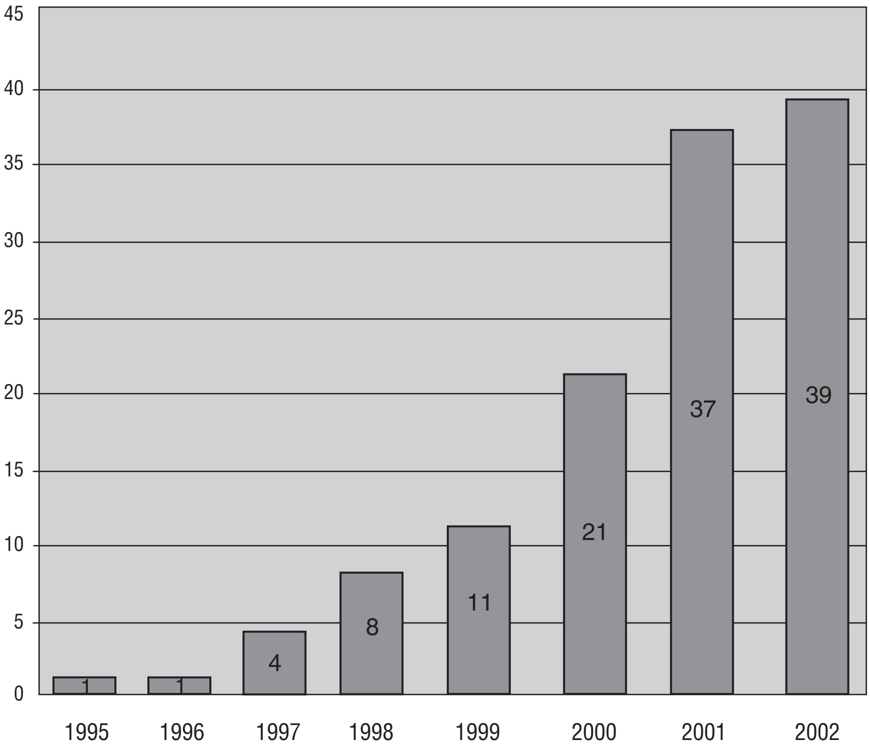

Fig. 1. Number of reported digital audio reserves projects, 1995–2000

factor in selecting a streaming format is institutional support. Most campus information technology departments have had some experience with streaming media, and by this time they have developed preferences for specific formats and decided aversions toward others. Some staff in academic computing, for example, are opposed to proprietary formats and choose to support only open-standard formats like MP3. Others prefer to support only those formats with a substantial market share, since a large user base promises more reliable technical support, fewer user complaints, and less risk of obsolescence. Still others support particular formats because of their ties to particular operating systems and hardware (QuickTime, for example, with Apple, or Windows Media Audio with Microsoft).

A couple of respondents alluded to troubles they had encountered with their campus technology office over support for specific formats.

One librarian had completed a pilot project using one format but then was forced to repeat the project the following year when his campus withdrew support for his preferred format. Another respondent works in an institution where the campus technology department's goal is to provide uniform support for a particular operating system, and for that reason the librarian was asked to adopt the streaming format associated with the chosen operating system; only after the librarian and server manager had encountered critical problems in their pilot project were they allowed to switch to a more reliable format.

Among the thirty-nine surveyed libraries, the most common streaming format is RealAudio, accounting for twenty-nine (67 percent) of the forty-four responses (see fig. 2).[18] Eight use QuickTime (18 percent), five use Layer II or III of MPEG-1 (11 percent), one uses Windows Media Audio (2 percent), and one uses Shockwave (2 percent).

In the early days of streaming audio, the server supplying the stream ran software designed specifically for the chosen streaming format. Support of multiple streaming formats required multiple server programs often running on multiple servers. This requirement is changing as companies expand the capabilities of their server software to handle multiple formats with the hope to increase their market share.[19] At the present time, however, most libraries use server software developed specifically for their chosen streaming format. Since RealAudio is used by twenty-nine libraries, it follows that a comparable number (twenty-five) use RealServer to deliver the audio. The only other server software reported by more than one respondent are Windows Media Server and QuickTime, with two each.

The content for reserve listening is taken from compact discs, LPs, and sometimes tape recordings. Software is required to translate the sound into an uncompressed sound file, to edit it (for example, to remove dead air from the beginning or end or to add an announcement), and then to encode it as a compressed file ready for streaming. Some libraries also "clean" the sound to remove pops and clicks from worn disc recordings. The number of steps required for the encoding process depends on the capabilities of the software, and different software is often used for each step.

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18. When asked about the streaming format used with their digital audio reserves projects, four of the thirty-nine respondents reported that streams are offered in multiple formats. For this reason, I considered the total number of responses to be forty-four rather than thirty-nine, taking into account three libraries streaming in two formats and one library in three formats.

19. For example, in July 2002, RealNetworks announced the release of its Helix Universal Server, which streams not only RealAudio, but also QuickTime, MPEG-2, MPEG-4, Windows Media, and dozens of other formats.

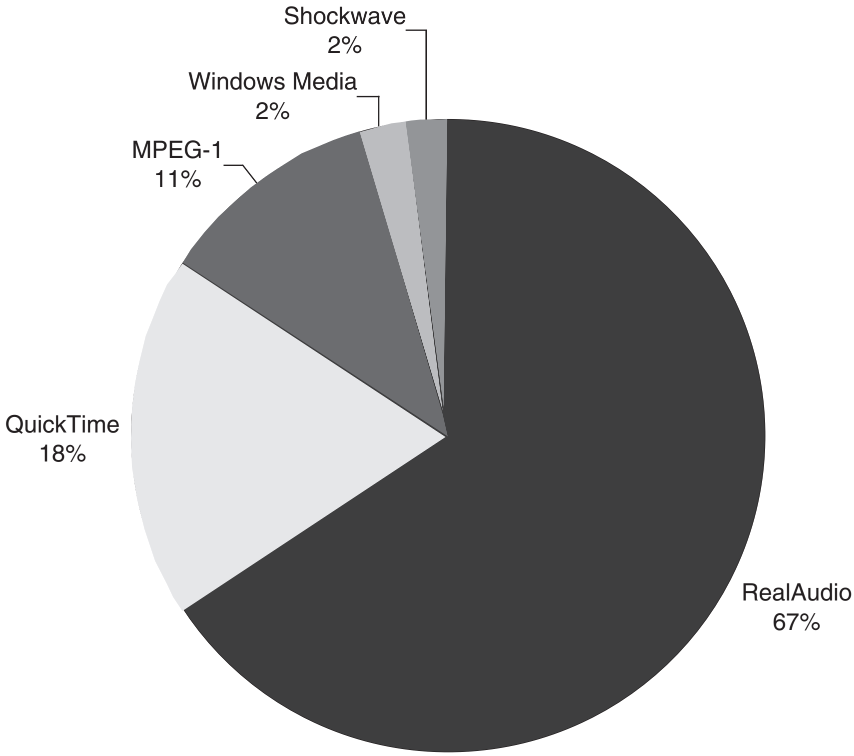

Fig. 2. Streaming audio formats used by digital audio reserves projects

When asked to list all of the software used to create digital audio files, the respondents mentioned a total of twenty-four different programs, seventeen of which were mentioned by only a single respondent. Three were used by more than five respondents: RealProducer (twenty-one), Sound Forge (thirteen), and Media Cleaner Pro (seven).

Playback of streaming audio requires client software, and like server software, playback clients are often designed for use only with specific streaming formats. This trend also is changing, as software developers strive to increase their market share by making their media players more versatile. Twenty-seven (69 percent) of the respondents report that their listeners use RealPlayer (the client developed and supported for use with RealAudio), six (15 percent) use the QuickTime player (designed for use with Apple's QuickTime format), three (8 percent) use Windows Media Player (a Microsoft product that can stream a number of audio formats), two (5 percent) use proprietary clients developed by their institutions, and one each (3 percent) use SoundJam and Streamworks Player. Four libraries support more than one client for playback of the audio streams.

Most streaming formats allow sound to be delivered over the network at different speeds. The higher the rate of transmission, the better the sound, since faster speeds allow more data to be sent in real time through the network, and the increased data yield higher fidelity. Faster transmission speeds therefore require larger sound files, which in turn require larger amounts of storage space.

In the late 1990s, when most remote users dialed up to networks using 28.8 kbps modems, low-fidelity streams were the only option for remote access, and users accepted the trade-off between convenience and audio fidelity. Many of these early streams sounded no better than an AM radio, but on the other hand a reserve tape that had been played hundreds of times often sounded much worse. Students were accustomed to listening beyond the tinny sound and hiss to hear the music.

Advances in network speed have come quickly. Now that most dormitories have Ethernet access and a growing number of home computers are connected to the Internet using relatively fast cable-modem and DSL lines, students find low-fidelity streams unacceptable. Also, large audio files can now be stored easily on large, relatively inexpensive server drives.

Thirty-six of the thirty-nine respondents provided information on streaming speeds (see fig. 3). Several libraries are encoding for delivery at multiple speeds (or using technology that delivers streams at multiple speeds from a single file) in order to accommodate both slower, dial-up lines and faster cable-modem and Ethernet connections. Twenty-three of the thirty-six libraries responding to this question (64 percent) are encoding to deliver streams at a speed of 96 kbps or faster, and fifteen (42 percent) for streams at 132 kbps or faster. These streams produce audio quality that is superior to FM radio and approaches CD quality.

Equipment

Digital audio projects require computer equipment, software, and—depending on the type of source recordings—audio components. All thirty-nine libraries are encoding compact disc recordings. In fact, six libraries have limited their projects to compact discs. Most libraries devote a single computer to encoding; for work with compact discs, no other equipment is needed, provided the computer is equipped with a CD-ROM drive. (One enterprising librarian has launched a small reserve-listening project with nothing more than a laptop.) Twenty-four (77 percent) of the thirty-one respondents to this question, however, reported that their libraries are digitizing LPs as well as compact discs, and these

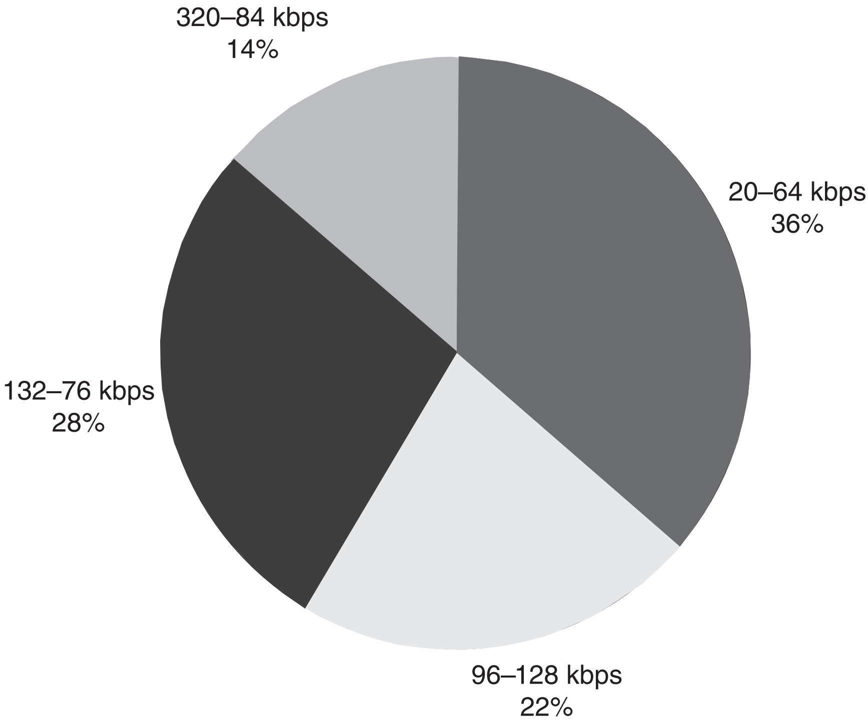

Fig. 3. Streaming rates used by thirty-six digital audio reserves projects

installations require the addition of at least a turntable and amplifier. The choice of additional components depends on the medium of the source recordings. To work with tape recordings, libraries add whatever components are appropriate, such as cassette, reel-to-reel, and DAT decks. Libraries also engaged in preservation work may use disc-cleaning machines, mixers, filters, and equalizers. The basic installation, however, used by seventeen (55 percent) of the thirty-one libraries, consists of a computer with a CD-ROM drive, a turntable, a cassette deck, and an amplifier.

Archiving

The file standards and software used for streaming audio continually evolve to take advantage of advances in computer hardware and network technology. As the technology changes, a library might choose to abandon its current streaming format for a better one. When migrating to a new format, the compressed sound files used for streaming must be recreated in order to conform to the new standard. One way to reduce the amount of work required to recreate the compressed files is to retain copies of the uncompressed source files in order to skip the initial step of the encoding process. Storing the source files requires extra time and large amounts of storage space, but for digitization projects involving LPs and tape recordings, it is advisable, and for preservation projects, it is essential, since the format and condition of the source recordings might rule out redigitization, and one of the means, after all, of preserving these recordings is to limit the need to access them.[20]

For an audio reserves project based primarily on compact disc recordings, storage of the digitized source files is optional. The discs themselves can serve as a backup, the audio data on the discs will not be changing with use over time (at least in theory), and the encoding process itself requires a smaller commitment of time. While LPs, tape recordings, and other analog media must be encoded in real time, a compact disc recording, being a set of data files, is encoded as quickly as the computer can read and convert the data from the disc—often in less than half the time it would take to play the recording.

Three media are commonly used to store the uncompressed source files: recordable CD-ROMs (CD-Rs), hard-drive space on a server, and tape. Each method has advantages and disadvantages. By transferring the files to tape or CD-Rs, they are archived on a physical medium apart from the encoding computer and the server. The discs or tapes can then be stored, transported, and used independently of the digital audio project. On the other hand, as physical objects, tapes and discs deteriorate and can incur damage, and as media formats, they are subject to obsolescence. Storing the files on a server places the burden of preservation on the operator of the server, and it assumes a level of trust in the operator's commitment to backing up the server's data regularly and storing the backup media in a safe and secure location. Of course, all three media are vulnerable to catastrophes—there is no medium that is not, least of all the original sound recordings themselves.

Twenty (51 percent) of the thirty-nine libraries store archival copies of source files. These libraries use one of the three common methods for storing data files: thirteen (65 percent) use CD-Rs, five (13 percent) use hard disk space on a server, and two (5 percent) use tape.

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20. Virginia Danielson reported in 2000 that four copies were being made of recordings digitized for Harvard University's "Music from the Archives" project—two on CD-Rs (for users) and two on computer data tapes (for storage): "With very modest investment of time and money, we can make two copies of the CD using products from two different manufacturers and two copies of the exabyte tape using two different lots of tape." "Stating the Obvious: Lessons Learned Attempting Access to Archival Audio Collections," in *Folk Heritage Collections,* 11.

Collections

Copyright

Once the sound has been encoded and placed on the server, it is ready for access by the public. The question then becomes how to define "the public." Because most recordings placed on reserve are commercial recordings protected by copyright, the definition of "the public" must be considered carefully. Libraries often are required to work with their campus legal office to make sure that access to digital audio falls within fair use, and some legal offices are more risk-averse than others. In fact, even with the promise of restricted access, some campus legal offices have refused to authorize the implementation of digital audio projects involving commercial recordings.

In February 1996, the MLA Legislation Committee issued a statement supporting the digitization of reserve materials and their delivery over networks.[21] The statement cites section 110 of the copyright law, which authorizes the use of a copyrighted work (or a "lawfully made" copy of the work) in "a classroom or similar place devoted to instruction," and then expresses MLA's endorsement of three key assumptions related to section 110:

(1) "the library reserve room may be considered an extension of the classroom";
(2) "students enrolled in a class have the educational right to aurally access its assigned musical works both in the classroom and through class reserves"; and
(3) "the dubbing or digital copying of musical works for class reserves falls within the spirit of the fair use provision of the copyright law."[22]

This preamble leads to the heart of the statement, a set of practical guidelines for keeping a digital reserves project within the boundaries of fair use:

- Access to such digital copies must be through library-controlled equipment and campus-restricted networks.
- Access to digital copies from outside of the campus should be limited to individuals who have been authenticated: namely, students enrolled either in a course or in formal independent study with an instructor in the institution.
- Digital copies should be made only of works that are being taught in the course of study.
- Digital copies may be made of whole movements or whole works.

21. Music Library Association, "Statement on the Digital Transmission of Electronic Reserves," c1996–2002, http://musiclibraryassoc.org/Copyright/ereserves.htm (accessed 27 November 2002).
22. Ibid.

- Either the institution or the course instructor should own the original that is used to make the digital file. The library should make a good faith effort to purchase a commercially available copy of anything that is provided by the instructor.
- The library should remove access to the files at the completion of the course.
- The library may store course files for future reuse. This includes the digital copy made from an instructor's original if the library has made a good faith effort to purchase its own copy commercially.[23]

The survey included several questions that address these conditions in order to determine how existing digital audio reserves projects measure up to the guidelines.

None of the libraries surveyed seeks copyright clearance for the network delivery of commercial recordings, but all impose restrictions on access to their networked audio. Thirty-three (85 percent) of the thirty-nine respondents report that they offer access through any computer connected to the Internet but restrict access through password control. Ten (26 percent) provide open access in specific buildings on campus but require a password for off-campus access. Six (15 percent) restrict access to particular buildings on campus and offer no off-campus access.

Twenty-six (67 percent) limit access to students enrolled in the individual courses, usually through course management software adopted by the campus, such as Blackboard, WebCT, or ERes. Ten (26 percent) extend access to all students, staff, and faculty by using an established campus-wide authentication system. Two (5 percent) extend access to anyone using authorized computers on campus.

Nearly all of the libraries also take steps to prevent users from making unauthorized copies of commercial sound recordings. Most use streaming servers that make it difficult—but not impossible—to save files. (Even a fairly unsophisticated, but determined, user can capture the audio output from a soundcard and store it as a file.)

Only four (10 percent) of the respondents regularly digitize recordings not owned by the library. The others strive to digitize only recordings owned by their institutions, but seventeen (44 percent) will digitize a recording not owned by the library while making a good faith effort to acquire the recording for the collection. Four (10 percent) of the respondents will encode tracks from commercial anthologies intended for purchase by students.

23. Ibid.

Organization and Method of Access

In order to be usable by the public, a collection of digital audio files, like any library collection, requires description, organization, and access points. Among the respondents, no consistent method is in place, and because of minor variations among the different approaches, it was difficult to compile reliable statistics.

Libraries use one or more of three methods to provide a user interface for the audio files: Web pages, a course-management program adopted by the campus, or hypertext links in the online catalog. Web pages are the most common interface, used by seventeen (44 percent) of the respondents. A growing number of campuses are adopting course-management software to handle syllabuses, class assignments, and reserve lists, and fourteen (36 percent) of the respondents are integrating links to sound files into course entries on these systems. Eight (21 percent) of the respondents report use of their library systems' online catalogs for access to audio reserves.

When using an online catalog as the user interface, libraries provide description and access through the existing cataloging records for the recordings. For course-management systems and Web pages, however, the track descriptions and composer (or performer) statements more often are transcribed directly from the recording in hand; the descriptions conform to no accepted standard for description, and the access points are not subject to authority control. At least one library adapts metadata from the Compact Disc Database (CDDB), a central repository of album and track descriptions that is accessed by computer compact-disc players via the Internet. The database offers a quick way to acquire data on the contents of a compact disc, but because the data are contributed by volunteers, format and accuracy are inconsistent.[24]

The electronic files themselves are identified using diverse methods, and again there is little consistency: libraries assign names based on the local call number, bibliographic control number, barcode number, CDDB number, or some combination of course name, number, and instructor name. Of these, naming files based on the local call number is the most popular method, used by fourteen (36 percent) of the respondents.

24. For more information on the CDDB database, see http://www.freedb.org (accessed 27 November 2002).

Staffing

The planning, implementation, and ongoing management of a digital audio reserves project involves a considerable amount of work by staff on all levels. The staffing requirements for a project vary depending on its scope: some of the reported projects cover only one or two courses; others, over ten. For this reason, it would be difficult to use the survey responses to estimate the staffing needs of a specific digital audio reserves project; nevertheless, the responses reveal that many of the projects are similar in scope, and a picture emerges of the staffing requirements of a typical project.

In the early stages, librarians and administrative staff typically make decisions on the project's scope, process, and infrastructure. Once the work of the project is underway, most librarians are involved no more than an hour or two each week. At this point, the workload shifts downward to lower-level staff and students. The average digital audio reserves project is maintained by staff or students working ten hours or less each week; larger digital library projects and projects involving preservation, however, can employee up to 2.5 FTE staff.

Staff time is costly, and librarians considering the possibility of mounting a digital audio reserves project might see the need for increased staffing as a stumbling block. At least two-thirds of the projects, though, were put into place with existing full-time staff. In some of these cases, student-assistant hours were added for work on encoding.

Digital audio reserves projects usually are the product of collaboration between the music library, the central library, and the campus technology office. The encoding is typically the responsibility of the music library, but at least one library expects this work to be done by teaching assistants or faculty. The server is usually maintained by either the central library or the campus technology department. In only three cases is the server the responsibility of the music library.

With nearly forty libraries encoding sound for reserves, there surely has been duplication of effort as dozens of libraries have encoded the last movement of Beethoven's Ninth, *The Rite of Spring,* "Sumer Is Icumen In," and other reserve-list classics. Libraries could eliminate this redundancy by sharing encoded files, but there are several reasons why this kind of collaboration is not occurring. Because libraries use different streaming formats and transmission rates, sharing encoded files is not particularly useful. Furthermore, sharing the large, uncompressed files is not practical, since transmission of these large files is relatively slow, and storage of a large number of them on a server would be costly. Also, each reserve project has unique requirements. Instructors often request a specific performance of a work, and that recording might not be the one encoded by a collaborating institution. Perhaps the biggest obstacle to sharing files is the need to devise a system that would allow the participating libraries to work within the guidelines of the MLA statement without undue burdens: if a librarian is expected to provide network access only to those recordings held in the local library's collection, for example, the librarian should not be allowed to use a contributed digital file without first confirming that the source recording is among the library's holdings. How could the cooperating libraries make sure that the librarian does not misuse a contributed file?

Costs

The questionnaire asked the respondents to estimate the cost of implementing and maintaining their digital audio projects. Again, the figures vary widely, depending on the scope of the project. Because of the need for specialized equipment, preservation projects are expensive to put in place, while reserves projects can be launched with a fairly small budget. For those institutions engaged in both preservation and audio reserves, it is often difficult to distinguish the costs related to the two activities, since the same equipment and personnel are often used for both. Looking at the institutions involved solely in reserves, however, some conclusions may be drawn about the average cost of implementing and maintaining that type of project.

The startup costs for digital audio reserves projects have ranged anywhere from nothing (in the case of the librarian using his own laptop) to $900,000 (for Indiana University's renowned digital music library project, developed in partnership with IBM, and whose scope is far broader than simply delivering reserve listening). Nearly half the projects, however, were launched for less than $5,000. Ongoing costs also varied considerably, but half of the respondents plan to spend less than $3,000 for the annual maintenance of their projects, excluding staffing.

WHAT LIES AHEAD

In addition to digitizing audio for class reserves, several libraries have been scanning related printed texts and music. A few libraries are building on existing media streaming technology to synchronize the display of scanned images with the playback of the sound, making it possible, for example, not only to have the score of Mozart's *Don Giovanni* display on a student's computer but also to have the pages turn automatically as the music is being played, and to provide English translations of the Italian text in a separate window—all of which might raise the question of whether there is a point where technology makes the life of a student just a bit too easy.

The ability to combine audio and images can also offer librarians a means of assembling multimedia research tools. Plans for Harvard University's "Music from the Archives" project include

> a thoroughly integrated multimedia finding aid . . . in which the digital resource itself will be conceived as having multiple manifestations. Whereas now we can move from one set of digital objects to another, our plan is to produce a more flexible tool that will allow us to show relationships among parts of our collection that may not be readily apparent to the user—for example, among a festival program book, a photograph, a concert program, and a recording.[25]

So far, digital music library projects have been independent initiatives, for the most part taken on by institutions working in isolation. For preservation projects, this approach makes good sense, since the recordings being preserved are often unique holdings. For reserve projects, the prospects for cooperative encoding will continue to be unfavorable because of the difficulty in setting up a distribution system that will ensure compliance with the copyright law. A more likely development is the growth of online subscription services that will offer sizeable libraries of recordings to the public. In the world of print, we have seen rapid growth in electronic-text subscription services during the past decade, the result of vendors arriving at a model that protects the publisher's rights, generates appropriate royalties, and is affordably priced. Will a similar model emerge for sound recordings? Reasonably priced subscription services to substantial collections of commercial sound recordings would benefit both consumers (including libraries) and the recording industry by providing a practical alternative to the free file-sharing services, such as Napster, that the industry has worked, actively and somewhat successfully, to shut down.[26]

CONCLUSION

In the 1980s, libraries began using new computer audio technologies to encode sound as a means of preservation. By the mid-1990s, streaming audio technology allowed libraries to deliver sound to users over existing networks, and established audio preservation programs then had a

25. Danielson, 10.

26. We are seeing some movement in this direction. The Naxos recording label (see http://www.naxos.com) now offers network access to thousands of individual tracks from its large library of recordings. The service is available to individuals free of charge, and licensing agreements are available for the commercial use of individual tracks. Although the streaming rate, at 20.8 kbps, is not optimal, the existence of the Naxos service confirms that the technology needed to provide libraries with licensed access to commercial recordings is already available to the recording industry.

means for providing easy access to formerly restricted recordings, to the point that the distinction between preservation and access soon became blurred.

Because the new streaming technology could accomodate heavy use at odd hours from a variety of locations, other libraries quickly saw the value of applying the technology to reserve collections. Falling prices and advances in computer and network speeds have enabled libraries to mount digital audio reserves projects with a minimal commitment of staff and resources, and audio reserves have become the most common application of digital audio technology in music libraries. By 2002, several dozen libraries had launched digital audio reserves projects using a variety of streaming formats, encoding rates, and methods of access. The large majority of the libraries work within the restrictions stated in MLA's "Statement on the Digital Transmission of Electronic Reserves" to keep projects within the limits of applicable intellectual property laws.

For many libraries, what started as a pilot project to test the feasibility of using streaming audio for reserves quickly became the preferred method of delivery. Network access to recordings is not only possible, it is what users familiar with the Web have come to expect. There is no turning back, but we can move ahead with some confidence that further technological advances will eventually make our current digitization work obsolete, requiring reformatting, and in some cases redigitization. The train has left the station, and we await what lies around the bend, not knowing how soon we will need to switch trains or how much baggage we will be dragging behind us.