5. Using external media: CDs, DVDs and removable USB storage devices

(This section last updated August 2007)

This section of the *Users' Guide* covers usage of portable data storage devices, including compact discs, DVD discs and external USB disk and flash drives, and includes the following major topics:

☞ *Compact discs :*
- playing audio cds and "ripping" (extracting) samples from audio cds into hard disk soundfiles
- recording and copying audio cds
- creating data cd backups

☞ *DVD discs:*
- creating data DVDs
- preparing and then making DVD-Audio format discs
- playing DVD video discs

☞ creating calibration tones

☞ using the ECMC library of sound sources available on cds

☞ using flash drives and external USB drives

5.1. Audio and data compact discs

Compact discs can be used to record either audio or computer data. The following types of compact disc decks are in widespread use:

1) *Audio cd players*, connected to stereo playback systems, used to play audio compact discs

2) *CD-ROM* drives connected to computers are used to extract data from cds onto the computer system, and often to play audio cds through the computer's audio system as well. (Often this requires installing a small audio cable internally between the cd-rom drive and a cd input on the sound card.)

3) *CD recorders* (or "burners") can record audio samples or digital data to cd discs. Two types of recordable discs are in common use:

   ☞ *CDR* ("*r*ecordable") discs can only be written once.

   ☞ *CD-RW* ("re-*w*ritable") discs can be re-used many times — up to a thousand times, according to some specifications — but must be erased (blanked) each time before they can be re-written. One cannot append to a previously written CD-RW disc.

   In addition to their recording capabilities *cd recorders* also can function as CD-ROM readers to extract data from cds.

Commercially manufactured cds user lasers to burn tiny pits into the surface of the disc. By contrast, CDR and CDRW do not contain a pitted surface, but rather a very thin coat of dye, that is melted by a laser into light-and-dark patterns that simulate the pitted surfaces of commercially produced discs. Fortunately, most stand-alone CD audio players manufactured within the last few years are able to read CDR discs without problems. CDRW discs, however, cannot be played reliably, or at all, on some stand-alone audio cd decks. To be safe, always record audio cds to CDR discs. CDRW discs are best suited to data backups, since they can be re-written as a file system changes.

CDR and CDRW discs also can be read by almost all recent DVD drives included in desktop and notebook computer systems. Audio CDR discs also can be played on *some* stand-alone DVD-video decks, including almost all DVD decks that can play DVD-Audio format, but once again CDRW disks are more problematic with some consumer (and even with some professional grade) DVD players.

Computer system CD-ROM, CDR and CDRW decks can be either *internal* (housed within the computer tower or laptop enclosure) or *external* (contained within an metal external box attached by a cable to an IDE/ATAPI or SCSI port on the computer). ATAPI drives are cheaper and more common. However, the software that controls cd recorders usually employs SCSI emulation, "tricking" the operating system into thinking that an IDE deck is a SCSI device. SCSI subsystems offer faster speed and more reliable I/O than IDE.

Audio cds

Audio cds are written according to a *Red Book* standard as 44.1 kHz 16 bit stereo samples in a special format called *CDR*. The disc is divided into tracks and sectors, where each sector includes 2352 bytes, equal to 1/75 second of sound. Each soundfile is written to a separate track, which may be up to 1 second longer than the source soundfile, since the final sector is padded with zeros until it reaches 2352 bytes. Most often, each track is preceded by a silent two second *pre-gap*, and the first track actually begins at absolute time 2 seconds rather than at 0 seconds. There can be up to 99 tracks on a cd, and each track must be at least four seconds long. Most cds hold up to 74 minutes of audio, although 80 minute discs also are available. A table-of-contents near the beginning of the cd holds information about track durations and the layout of the disc, and may include text data (identifying title, composer, performer(s) and similar information). In normal playback mode, the data from an audio cd is read at a rate of about 172 kB per second.

Standalone audio cd decks include fairly sophisticated error correction circuitry that enables the deck to "calculate" (through interpolation) short segments of samples that cannot be read successfully from the disc, even after oversampling re-tries. Many stand-alone audio cd players also employ a (widely misunderstood) technique called *oversampling*, which is not a form of error correction, but rather a technique of raising the playback sampling rate by interpolating between adjacent samples written on the disc. This enables the manufacturer to use a low pass filter with a much gentler slope, and to begin the filtering at a higher frequency.[1] In some cases the resulting audio will sound "smoother" or "airier."

The software cd player applications available on computer systems typically include less sophisticated error correction capabilities, or (more often) none at all. Thus, a disc that seems to play fine on your home stereo system may produces glitches when played on a computer system. Such problems may lie on the disc (e.g. a scratch, or a bad sector), or in the hardware or software of the computer system (buffering problems, interrupts, a bad cable, etc.). If the garbage occurs at exactly the same spots on successive plays, the problem most likely lies on the disc, but these imperfections still may be inaudible on playback decks with error-correction. Software cd applications rarely include oversampling procedures, and do not always employ high quality smoothing filter algorithms. Thus, an audio cd may sound "harsher" when played back on a computer system than when played on a high quality audio cd player.

Data cds

Recordable compact discs also can be used to back up all types of hard disk files (soundfiles, ascii files, image files etc.) and to archive complete directories of files. Files saved to a data cd then can be restored or copied to another computer system at any time. The storage capacity of most cds is 650 MB, of which about 620 MB of space is available to the user. (A small portion of the disc is lost to formatting and filesystem information.) 800 MB discs also are available, but not all cd burning programs recognize or support this larger capacity.

Unlike audio cds, a *CDR* or *CDRW* disc used for data backup most often is formatted according to a cross-platform file system called *ISO-9660*, which can be read by Linux/Unix/Macintosh systems and by Windows systems. On data cds, all of the files usually are written within a single, continuous track, rather than in a one-file-per-track format as on audio cds. The basic *ISO-9660* filesystem employs the irksome 8+3 *DOS* limitation in the length of the names of files and directories to be burned on the cd. However, on Unix/Linux systems the *Rock Ridge* extension system, which customarily is added to the ISO standard, allows long file/directory names and saves file permissions. On Windows systems, the Microsoft Joliet extensions allow long file names. Rock Ridge and Joliet extensions both can be included on a disc.

Compact disc decks, and the (CDR and CD-RW) discs themselves, are rated for the speed at which they can transfer data. The speed rating is a multiple of 150 kB per second, the data transfer rate of the earliest cd-rom decks. Most current cd-rom decks can read data into the computer at somewhere between 40 and 60 times this benchmark. CDR decks have two speed ratings. The first number is a write speed, and the second number is a read speed. Typical write speeds today are between 16 and 52 times the 150 kB/sec benchmark. CD-RW decks have three speed ratings — the first for writing CDR discs, the second for writing to CD-RW discs, and the third for reading discs. Typical write speeds for CD-RW discs are between 4 and 24 times the benchmark figure.

[1] For more technical information on oversampling see *http://www.earlevel.com/Digital%20Audio/Oversampling.html*

To achieve the maximum CDR or CD-RW write speed of which a deck is capable, however, one must use discs rated for this speed. CDR discs manufactured more than a year or two ago, and some cheaper current discs, have maximum write speeds much lower than the speeds supported by current drives, and cheaper CD-RW discs often have a speed rating of 4x. CD burners and their software drivers read a disc label to determine its maximum speed and adjust the write speed accordingly.

Data CDs contain a file system, which must be *mounted* ("attached" to the existing file system) before it can be accessed, and then *unmounted* before the disc can be ejected. By default, Windows and Macintosh systems, and most Linux distributions (currently including *madking*) employ *autopolling* to handle these tasks automatically. System software examines the cd/dvd device frequently to see if a disc has been inserted or ejected, and to determine whether a the data on a newly detected disc is organized according to a recognizable file system format. If so, the disc is mounted and a browser window opens to display its contents, indicating that the disc is ready for use. When cd polling software is running, ejecting a disc automatically *unmounts* the disc, so that the operating system can maintain an accurate, updated listing of all files currently accessible on the system. On *madking* you can unmount a cd or dvd disc by typing

eject

in a shell window, or else by pushing the Eject button on the caddy of the Plextor dvd/cd drive on the case of the computer. Before unmounting a disc, however, you should quit any applications that are accessing files on the disc (except for the browser window for the disc). Usually the operating system will prevent you from ejecting the disc while it is still being accessed by some application.

Autopolling is convenient for the user, but it does add to system overhead, thus degrading system performance somewhat, and for this reason it is turned off by some system administrators and in some Linux distributions. Manual mounting and unmounting of cd and dvd discs by the user can save machine cycles for more important tasks, but also can be somewhat bothersome for the user.

Audio cds do not need to be mounted or unmounted, since they do not contain a file system. Likewise, blank cds, or cdrw discs that you wish to overwrite, do not need to be mounted before you can burn data to them, since the disc does not need to be read.

When a previously created data cd or dvd is inserted in a dvd/cd drive, it is attached to the file system at a *mount point* — a "node," or branch, of the full file system. In Fedora Linux distributions, the mount point for external storage devices such as compact discs, dvds and removable disk drives is */media*. Data compact discs and dvds also have a label name, either supplied by a manufacturer (for commercial cds) or by a user when (s)he burned the disc, or else by the disc burning application. To find out the label name of a disc after it has been mounted, type the command

df -h

in a shell window. This will display a list of currently mounted disk partitions, additional system file systems and external storage devices, along with information on the size and available free space for each entry. Near the bottom of this list you should find an entry for the data cd that looks something like this:

Filesystem	Size	Used	Avail	Use%	Mounted on
/dev/scd0	169M	169M	0	100%	/media/K3b data project

In this example, the full mount point for the data cd is *K3b data project*. The unwieldy disc name *K3b data project* is the default name provided by the cd/dvd burning application *k3b*, and it appears as well in the titlebar of the browser window for the disc.

Once a data cd has been mounted, you can copy files from the disc onto system hard disks by dragging icons from the cd browser window into browser windows for your Unix or soundfile directories. Alternatively, you can use standard Unix commands such as *ls* and *cp* in a shell window to perform these operations. Since the repugnant disc name *K3b data project* includes two spaces, the full mount point must be enclosed in double quotes on the second line below.

df	[find out the path to and name of the disc]
pushd "/media/K3b data project"	["move yourself" onto the cd; make it your current working Unix directory]
ls	[list the folders and files on the cd]
cp riffs1 riffs2 ~/Project	copy files *riffs1* and *riffs2* to your Unix folder *Project*]

mv Sounds	["go into" the folder *Sounds* on the cd]
*cp * $SFDIR*	[copy all soundfiles in the cd *Sounds* folder to your current working soundfile directory]
popd	[return to the Unix directory in which you were working before you "moved yourself" to the cd; be sure to "move yourself" out of the cd before you eject it]
eject	[unmount the cd and eject it from the disc caddy on *madking*]

5.2. Playing and ripping audio cds

On *gesualdo* and other Windows machines the applications *Windows Media Player* and (if it is installed) *WinAmp* can be used to play audio cds loaded into a system cd drive. On Macs, the *iTunes* application generally is used for this purpose. On Linux systems, there are several graphical audio player applications, such as *cdplayer*, *Audio player*, *Amarok*, *Audacious*, and *Rhythmbox* that are capable of playing audio cds. These applications can be opened by selecting *Applications->Sound and video* on the taskbar. Many of these media player applications can also play WAVE, MP3, ogg vorbis and other soundfile formats as well.[2] However, these applications can be slow to open and in some cases require that the user configure or specify the location of the cd device (currently */dev/scd0* on *madking*).

Because we have not been fully satisfied with any of these graphical Linux cd playing utilities, we have incorporated a much quicker method for playing audio cds within the all-purpose ECMC **play** command, which can be used at any time, whether or not *jack* is running. When using the *play* command, specify consecutive tracks to be played from a cd by enclosing the track span in underscore characters.

*play _2_*	will play track 2 of the cd
*play _4-6_*	will play tracks 4, 5 and 6
*play _9_ ; play _7_ ; play _9_*	will play track 9, then track 7, then track 9 again

For more information and examples see the *man* page for the *play* command.
To list the contents of an audio cd, you can use the command *cdrip* -Q (discussed below).

Perhaps the only occasions on which you will wish to use one of the (comparatively slow) GUI cd playing applications, rather than the ECMC*play* command, is if you want to be able to skip around (fast forward and reverse) while playing a cd audio track. If *jack* is not running I recommend using the simple but functional Gnome *CD Player* application. If *jack* is running, you can use the *jack* client *Audacious*, either by typing

audacious &

in a shell window, or else by selecting *Applications->Sound and Video->Audacious* from the taskbar. To access the cd drive right click in the upper half of the *Audacious* window, then highlight *Playback* and then select *Play CD.*

On *madking*, compact disc **ripping** is accomplished more easily and quickly with shell commands rather than with graphical applications and utilities. Two full-featured Linux command line rippers come bundled with almost all Linux distributions: *cdda2wav* and the strangely named *cdparanoia*. Both are powerful but, because of their many options, complicated to use. *cdparanoia* offers better jitter and error correction and is *slightly* easier to use. Owing to the frequent syntactical complexity of these two programs, several graphical applications have been created to run on top of *cdparanoia* and/or *cdda2wav* in order to hide the "ugliness" of these programs from the user. However, the current crop of Linux GUI rippers — especially the ripping procedures in the *k3b* application — are poorly suited to the needs of most ECMC users and are clumsy for our purposes. These GUIs are optimized for ripping songs from commercial pop cds, downloading title/artist information on these tracks from an internet *cddb* database (such as *freedb.freedb.org*) and then encoding them into *mp3* or *ogg vorbis* files.

To simplify the extraction of samples from audio cds, therefore, we have created an ECMC shell alias command called **cdrip**, which runs *cdparanoia* with the flag options necessary to copy the samples into a *WAVE* soundfile on *madking*'s *snd* disk. The simplest usage of *cdrip* is to print the table of contents on an audio cd, by typing:

[2] *Rhythmbox*, however, is best suited for playing podcasts, internet radio stations and *mp3* files.

cdrip -Q

The resulting display will look something like this:

Table of contents (audio tracks only):							
track	length		begin		copy	pre	ch
1.	14582	[03:14.32]	0	[00:00.00]	no	no	2
2.	13665	[03:02.15]	14582	[03:14.32]	no	no	2
3.	12580	[02:47.55]	28247	[06:16.47]	no	no	2
4.	13910	[03:05.35]	40827	[09:04.27]	no	no	2
----- (several lines for additional tracks omitted here) -----							
TOTAL	350270	[77:50.20]	(audio only)				

The length of each track is displayed within square brackets in the third column (e.g. [03:14.32]) and the total length of the disc is shown at the bottom of this column ([77:50.20] in this case — a long disc!). The starting time on the disc for each track is displayed within square brackets in the fifth column (e.g. [00:00.00]). If the track has been copy protected, so that it cannot be extracted or copied, a "yes" will appear in the *copy* (sixth) column.

The square bracketed *length* and "*begin* time" values require some explanation, since they do not , as one might presume, indicate actual temporal durations. Audio compact discs are written in units called *sectors*, with 75 sectors equaling one second of music. Thus 25 sectors equals a duration of 1/3 of a second, and 37 sectors corresponds to a duration of approximately (but not exactly) 1/2 of a second. The values in square brackets are displayed in

*minutes***:***seconds***.***sectors*

Note that the sectors field, which specifies values smaller than one second, is preceded by a period rather than by a dot. Thus, the value [03:14.32] indicates a length of 3 minutes 14 seconds and 32 sectors, equivalent to a temporal duration of about 3 minutes and 14.427 seconds.

The syntax for ripping audio with *cdrip* is

cdrip [span] [outputstring]

The *span* argument, required unless we want to extract the entire cd, specifies the portion of the cd to be ripped. The optional *outputstring* argument is a character string to be included in the name of the output soundfile(s). If no *outputstring* argument is provided, the default name for the output soundfile will be the track number followed by the string *.cdda.wav*. The *outputstring* argument replaces the *.cdda.wav* extension, and should itself include a *.wav* extension.

In most cases we will want to extract one or more entire tracks from the cd. If we want to use only a portion of a track — say, a 7.33 second excerpt from time 3 seconds into the track to time 10.33 seconds — it is fairly simple to extract the entire track into a soundfile and then use a soundfile editor such as *rezound*, *audacity* or *sweep* to crop this soundfile, trimming off segments from the beginning and the end that we do not want.

Some example cdrip command lines:

(1) *cdrip 4-5*
Result: tracks 4 and 5 are ripped from the cd. The output soundfiles are named *track04.cdda.wav* and *track05.cdda.wav*

(2) *cdrip* (with no arguments)
Result: All tracks on the cd are extracted. The resulting soundfiles are named *track01.cdda.wav*, *track02.cdda.wav* and so on.

(3) *cdrip 6 risset.wav*
Result: track 6 is ripped from the cd. The output soundfile is named *track06.risset.wav*

(4) *cdrip 5 brahms.sym4.mov1.wav ; cdrip 8 brahms.sym4.mov4.wav*
Result: Track 5 is extracted into the soundfile *track05.brahms.sym4.mov1.wav* and then track 8 is extracted into the soundfile *track05.brahms.sym4.mov4.wav*.

It is possible to extract only a portion of a track with *cdparanoia*, and thus with *cdrip*, but the *span* argument quickly becomes fairly complicated: one must include an *skip time* in *seconds* and *sector* field, a

hyphen and then an *end* time in seconds and sectors. The following command specifies extraction of an excerpt track one beginning at 5 second 0 sectors into the track and ending at 15 seconds 60 sectors into the track.

cdrip 1[5.0]-1[15.60] excerpt.movt1.wav

Result: A 10.81 second excerpt is extracted from the first track, beginning 5 seconds into the track and ending at time 15.81 seconds. (60 sectors = approximately .81 seconds) This excerpt is written to a soundfile named *track01.excerpt.movt1.wav*

While *cdrip* (*cdparanoia*) is extracting it will display diagnostics on its progress. Toward the right edge of the display (but not all the way to the right) *OUTPUT SMILIES* will go whizzing by to indicate how things are going. The symbol you want to see is

:-) which indicates smooth extraction with little or no jitter detected.

Some alternative symbols that may indicate trouble, in order of increasing severity, include:

:-|	Normal operation, considerable jitter but output probably is okay
8-|	Finding read problems at same point during reread; errors hard to correct
:-(	Scratch detected; output might be okay but might not
;-(	Gave up trying to perform a correction
8-X	Aborted read due to known, uncorrectable error

cdrip most likely will handle all of your cd ripping needs, but it does include some defaults that on rare occasions you may not want. In such cases you will need to use *cdparanoia* or else a GUI ripper. A "getting started" introduction to *cdparanoia* is provided below in small type for such rare instances. Most ECMC users can skip over this primer and move on to section *5.3 Burning audio and data cds.*

5.2.1. Using cdparanoia

The syntax for *cdparanoia* (which can be abbreviated *cdpar* on ECMC Linux systems) is:

cdparanoia [flags] span [outputfilename]

where *span* indicates the portion of the cd to be extracted. If the optional *outputfilename* argument is not specified, the samples will be written to a soundfile called *cdda.wav (or cdda.aiff* or perhaps *cdda.raw*, depending upon the specified output format). The default format is WAVE. If you extract two or more tracks into separate soundfiles, these soundfiles will be named *track01.outpufilename, track02.outpufilename*, etc., or else (if you don't specify an "outputfilename") *track01.cdda.wav, track02.cdda.wav*, etc.

Flag options: For a complete list and description of all flag options consult the *man* page for the program. The following flags are generally the most important for our purposes. As with many Linux programs, these flags have both a "short" form and an alternative, mnemonic "longer" form:

short	*long*	*result*
-Q	--query	display the TOC (table of contents) of the cd and any error messages in accessing the cd-rom drive and disc
-w	--output-wav	output soundfiles will be in WAVE format (the default,so this flag is rarely used)
-f	--output-aiff	output soundfiles will be in AIFF format
-B	--batch	split the output into separate soundfiles at the track boundaries of the input cd ; normally you will want to include this flag when extracting more than one track; otherwise the individual input tracks will be written to one continuous soundfile (with 2 second pauses between the original input tracks)
-v	--verbose	verbose option, occasionally useful for debugging problems

The *span argument* (which should be enclosed in double quotes to guard against possible misinterpretation by the shell) specifies a beginning and/or an end point on the cd for the extraction. If no span argument is given the entire cd will be extracted. The span argument has the format:

(starting point for extraction) - (ending point for extraction)

"Track[hours:minutes:seconds.sectors]-Track[hours:minutes:seconds.sectors]"

Note that the *sectors* argument (which specifies times smaller than 1 second) is preceded by a dot (**.**) rather than by a colon (**:**).

Example cdparanoia command lines:

(1) *cdparanoia*

With no arguments, *cdparanoia* prints a usage summary.

(2) *cdparanoia -Q*

Result: Displays the TOC of the disc and exits.

(3) *cdparanoia -B*

Result: Extracts then entire cd, writing each track to a separate WAVE soundfile. The output soundfiles will be called *track01.cdda.wav, track02.cdda.wav*, etc.

(4) *cdparanoia -f "2-3" tracks2-3.aif*

Result: Extracts tracks 2 and 3 into a single, continuous AIFF soundfile named *tracks2-3.aif*

(5) *cdparanoia "1[::5]-1[::15.60]" excerpt.wav* or else
cdparanoia "1[5.0]-1[15.60]" excerpt.wav

Result: Extracts a 10.8 second segment from track 1, beginning at time 5 seconds and ending at time 15.8 seconds into the track, and writes the samples into a soundfile named *excerpt.wav* in your current working soundfile directory. (Note that 60 sectors = .8 seconds. Open a desktop calculator if necessary to make such sector-to-second conversions.)

(6) *cdparanoia "2[1:1]-2[1:10.38]" masterpiece.wav*

Result: Rips a 9 and a half second excerpt from track 2, beginning at time 1 minute, 1 second and ending at time 10 and a half seconds (38 sectors = approximately 1/2 second). The samples are written to a soundfile called *masterpiece.wav*.

5.3. Burning audio and data cds

All of the ECMC production systems include a combination cd/dvd burner. Some of our utility machines include only a cd burner. We periodically upgrade cd/dvd drives on the ECMC systems and swap drives between these systems, so any listing of the models and their speeds and capabilities available on various ECMC computers quickly becomes outdated. As of this writing, *madking* includes an internal Plextor model *708A* combination CD and DVD burner. The *708A* can write CDR discs at up to 40x and erasable CDRW discs at up to 24x, while reading cds at 40x speed. Remember, however, that in order to achieve 40x CDR write speed or 24x CDRW write speed, you must use discs rated for these speeds.

The cd/dvd burners in our four production machines — *madking* and *gesualdo* in room 52, *wozzeck* and *igor* in the MIDI studio — should only be used for the following purposes:

1) creating audio cds of works in progress or recently completed compositions.

2) backing up your soundfiles and other files (e.g. you */home* directory and its subdirectories on *madking*) that are currently in use for your electroacoustic work on this system. You should back up all of your important files frequently, and probably will want to make these backups to re-writable cdrw or dvd-rw disks so that you can re-use these disks.

The ECMC production system are not to be used to make audio or data cds for other purposes. Studio time and disk space are limited, and must only be used for your current compositional work in the studios. The ECMC studios do support burning for other purposes, such as copying cds, making cds of performances of your acoustic works on forums and other venues, and so on. However, all such "extracurricular" cd burning tasks must be done on the utility computer systems in room 53. This work also should be accomplished efficiently, in as short a time period as possible, so as not to tie up studio resources, especially disk space. Plan on devoting a concentrated burst of work to this project, finishing it within a day or two and then deleting the source files from the hard disk. Please be thoughtful of other users, and do not leave messes that our staff members need to clean up.

Many newer cd/dvd recorders, like the Plextor models in *madking* and in some of our our systems, incorporate a technology called *Burn-Proof*. The most common causes of "coasters" — cds with glitches that make the disc unusable — are buffer underruns: data is not available to the cd recorder at the instant it is needed. The Burn-Proof technology, sensing an impending buffer underrun, turns off and stops the laser until the buffer is reloaded, then resumes recording with no loss or gap in the data. However, even with this very nice feature, users should remember that cd burning is a real-time process and exercise caution not to overtax a computer system while cd burning is in process. Do not attempt processor-intensive or I/O-intensive tasks, such as deleting large files, or creating soundfiles, while burning a cd. While recording, it is fine to use a text editor, read email or surf the web (so long as you don't cache too many large web pages), but steer clear of applications such as *Csound*, *PD* and soundfile mixing programs that create a lot of disk input/output.

On Windows systems the best current applications for burning audio and data cds are *Nero Burning* and Roxio's *Easy Media Creator*, which is simpler to use but has fewer features. (*Nero*, for example, allows one to adjust the inter-track pre-gaps to durations other than the standard two second silences if you wish. *Easy Media Creator* currently limits one two two second inter-track gaps.) On Macinstosh systems simply inserting a blank cd or dvd disc will open a dialog box that will guide you through disc burning using commands from the *Finder*. Audio cds also can be assembled and burned from within the *iTunes* application.

On Linux systems the command line programs *cdrecord* and *cdrdao* are quite powerful, providing a great many options, but for this very reason can be difficult to use, at least initially. (Take a glance at the *man* page for either program and you will see what I mean.) Currently, *cdrecord* is better suited to recording data cds, while *cdrdao* provides better functionality for burning audio cds in disk-at-once (DAO) mode. Many graphical front-ends have been developed in attempts to provide a more intuitive, graphical interface for running *cdrecord* and/or *cdrdao* in the background. The most popular of these GUI burning applications is *K3b*, a fairly robust and easy-to-use applications that includes most or all of the features you likely will need when creating cds. Additionally, like the Windows *Nero Burning* application,[3] *K3b* can be used to burn data DVDs as well as audio and data CDs, and also can be used to copy CDs. Thus, by learning this one application, you can apply almost identical procedures to burn both CDs and DVDs.

5.3.1. Using K3b to burn cds

To open *K3b*, type: *k3b &*
in a shell window or else click on the *Applications* in the taskbar, then highlight *Sound & Video* and scroll down until you can select *K3b*. The first time you open K3b you should configure it by clicking on *Settings* in the *K3b* Taskbar and then on *Configure K3b*. The default settings should all work fine, but check to make sure that:

- on the *Misc.* page, *Used audio output system* is set to *alsa*, not to *arts*
- on the *Devices* pages the *Plextor DVDR PX-708A* is selected as the *Writer Drive*
  on the *Advanced* page, *Use Burnfree*, *Do not eject medium after write process* and *Automatically erase CD-RWs and DVD-RWs* should all be checked (unless you want to be prompted before overwriting re-writable discs. Should you prefer, manually erasing re-writable cd discs is as a separate operation is an option provided in the *Tools* menu.)
- There is one change I recommend, unless you want to hear a revolting sound effect accompanying all K3b error messages: on the *Notifications* page uncheck the box next to "Actions: Play a sound" and, for good measure, click on the *Turn Off All Sounds* button. Then click *Apply* and then *OK*.

When you open *K3b* you will be presented with the main menu, allowing you to choose one of four tasks:

(1) Burn an audio cd ("New Audio CD Project")
(2) Burn a data cd ("New Data CD Project")
(3) Burn a data DVD ("New Data DVD Project")
(4) Make one or more copies of a cd ("Copy CD")

Choose one of these four options to begin.

Burning AUDIO cds with K3b

1) Selecting *New Audio CD Project* from the main *K3b* menu opens a window with a browser at the top and an *AudioCD1* window at the bottom. Locate the soundfiles you want to burn in the browser. Double click on the *Root* folder in the left pane, then on the *snd* folder and then on your soundfile folder in the right pane. Find the soundfiles your want to burn and drag them into the *Current Projects* window.

Should you want to change the default two second silent gap between tracks, right click on a track and select *Properties*. In the *Audio Track Properties* window that opens, click on *Options* and raise or lower the *Pregap* value. On the same *Properties-->Option* page it is possible to uncheck the *Copy permitted* box, so that no additional copies of this cd track can be made. Generally this is not recommended. Then click on *Apply* and then on *OK*.

[3] A commercial Linux version of *Nero Burning* called *Nerolinux* is available at a cost of about $25, but is not currently installed on *madking*.

As you add soundfiles to the track list *K3b* will update the total program time in the bottom left corner and the available recording time on the disc in the lower right corner. If you want to change the track order, simply drag a track to a new position in the track list. will indicate the current size of the data to be written to the disc.

2) When you have included all the soundfiles you wish to burn to the CD, click on the Burn icon on the far left just above the track list, or else click the *Project* Taskbar tab and select *Burn*.

3) In the *Audio Project* window that opens you should not have to change any of the defaults. The speed should be set to *Auto* (*K3b* will choose the highest speed supported by both the CD drive and the disc). Check the *Simulate* box only if you want to do a dry test run before actually burning a disc. *Only create image* should NOT be checked. Click on the Burn button and recording should begin.

Burning DATA cds with K3b

Procedures for burning data cds (an data DVDs) with *K3b* are almost identical to the steps for burning an audio cds:

1) After selecting *New Data CD Project* from the main *K3b* menu locate the files and/or complete directories that you want to archive within the browser windows at the top and drag these down to the *Project* window. As you add more files and folders to the *Project* window, the green slider at the bottom will be updated to indicate the total size of the archive to be burned to the disc.

By default, *K3b* will not display your configuration dot files, nor include dot files within directories such as your home Unix directory. If you want to archive preference and configuration files such your *.bashrc*, your *Firefox* bookmarks (in ~/.mozilla/Firefox/USERID/bookmarks.html) and .ardour2 (your *ardour* preferences), right click on the browser window in *K3b*, select *View* and then select *Show Hidden Files*. (Unfortunately, this must be done every time you want to include hidden files in an archive. There is no way to permanently change *K3b*'s default practice of not displaying these files.) Now, if you drag your entire *home* Unix directory to the *Project* window, your dot files will be included in the archive.

If you prefer, you can drag icons for files to be archived from your Gnome file browser (rather than from *K3b*'s own browser window) into the archive list in the bottom half of the *K3b* window.

2) Give the disc a name in the *Volume Name* box. Do not include spaces or special characters. In the future, when you mount the disk this name will appear in the titlebar of the disc's browser window.

3) When all of the files and folders you wish to archive are contained in the *Project* window, click on the *Burn* icon. In *Data Project* window that opens, make sure that the recording *Speed* is set to *Auto*. If you want *K3b* to verify the integrity of the disc after it has been burned, comparing each cd file byte-by-byte with the original disk version of the file, check the *Verify written data* box as well. This is a good idea for important discs, but verification may take as long as the burning process itself.
When you are ready, click on the Burn button and recording will begin.

Note: Occasionally the erasure of a *cd-rw* disc before re-writing may seem to fail. If this happens, close the *Burn* window and try again.

After burning a CD (or DVD) disc, you should always test that the disc can be read correctly by an audio cd player or, for data discs, by the computer system. To check a data disc immediately after burning, you may need to eject and then reload the disc and then wait a few seconds until the operating system mounts the disc and a browser window for it opens. Display one or two of the ascii files on the data disk and make sure they look correct.

5.4. DVD discs

DVD discs are used in the ECMC studios for three purposes:

1) Backing up data, which may include soundfiles from your *snd* directory and its subdirectories as well as files from your *home* directory and its subdirectories.

2) Burning DVD-Audio (DVD-A) discs of soundfiles. Currently this can only be done on Windows system *gesualdo* in room 52 and utility Windows machine *fury* in room 53, the only systems that have the necessary proprietary software to prepare and create DVD-A discs.

3) Playing DVD-video discs, such as dvds of video works created for the *ImageMovementSound* festival and other video/audio works.

On Windows systems *Windows Media Player* is the principal application for playing video DVDs. The corresponding Mac application is *DVD Player* application. Some Windows and Mac audio applications, such as *Cubase* (available on both ECMC MIDI studio systems) and *Vegas* (available on *gesualdo*) also can import digital video from DVDs and other digital sources, and can be used to synchronize video and audio "tracks" and in the creation of multimedia works.

Playing video DVDs with MPlayer

Currently there are three applications on *madking* capable of playing video DVDs: *Totem*, *Xine* and *MPlayer*. We have had the best results with *MPlayer*. After inserting a video dvd disc into *madking*'s dvd drive caddy, open *MPlayer* by clicking on *Applications* on the titlebar, and then highlight

Sound & Video -> MPlayer (NOT "Movie Player," which opens *Totem*).

Alternatively, simply type

gmplayer & (if *jack* is not running) or else

gmplayer -ao jack & (if *jack* is running)

in a shall window. (The "g" specifies the graphical version of *Mplayer*.) A video display window and a transport window will appear on the desktop.

Right click in the main (video display) window and select *DVD->Open disc*. The disc probably will begin playing automatically. You can use the transport controls to stop, pause, fast forward and rewind. Right click in the main display window to toggle between half size, normal, double size and full screen, and to to change the aspect ratio, if desired. The square box near the center left edge of the transport also can be used to toggle back and forth between fullscreen and normal display.

Our focus in the remainder of this subsection will be on creating data and DVD-audio dvd discs. All of the four ECMC production systems contain a combination cd/dvd burner and software for burning data dvds. In fact, the procedures for burning dvds often are almost identical to those used in cd creation. As noted earlier in this *Users' Guide*, most DVD discs have a capacity of 4.7 G bytes (about 4.58 Gbytes)[4] and come in several formats:

dvd-r : until recently the most common and portable format; cannot be erased or reused

dvd-rw : a re-writable version of *-r* format, similar to *cdrw* format CD discs

dvd+r : a competing non-erasable format for long term storage that generally offers faster write speeds (less time to burn a disc); today *+r* format is almost as common as *-r* format for data backup purposes (but not for DVD-A authoring)

dvd+rw : a re-writable version of *+r* format, generally offering faster burn speeds than *-rw* format

[*Blu-Ray and HD-DVD* are two new, competing and incompatible high-resolution video dvd formats with much higher storage capacities than standard dvds. Blu-ray discs can hold 25 GB of data, 50 GB with dual layer, while HD-DVD discs can store 20 GB (single layer) or 40 GB (double layer). While currently used primarily with HDTV sets, blu-ray and hd-dvd drives soon should be available for desktop and notebook computer systems as well.]

The Plextor model 708A CD/DVD burner in madking

Before 2004 most DVD burners supported only *-r/-rw* formats or else *+r/+rw* formats. However, newer models, such as the Plextor model *708A* in madking, can burn to all four of these formats. Since the *708A* also can burn to *cdr* and *cdrw* discs, it is a "universal burner" capable of writing to all of the available CD and DVD formats in common use today. In addition to these burning capabilities, the *708A* can **read** discs in any of the following formats:

DVD : DVD-ROM single layer/dual layer, DVD-R, DVD-RW, DVD+R, DVD+RW

CD : CD-DA (Audio CD), CD-R, CD-RW, CD-ROM Mode 1, CD-ROM XA Mode 2, CD-TEXT Read & Write, Photo CD

[4] In 2006 dual layer discs were introduced with a capacity of 8.5 Gbytes. However, these larger capacity discs can only be used with recently manufactured dual layer-capable dvd drives.

The maximum *write and read* speeds for the *Plextor 708A*, and the maximum write/read speeds available as of August, 2007 on new burners, are:

format	maximum *708A* write/read speed	maximum speed available Aug. 2007
DVD-R	4x	18x
DVD-RW	2x	6x
DVD+R	8x	18x
DVD+RW	4x	8x
CD-R	40x	52x
CD-RW	24x	32x

Naturally you generally will want to burn discs at the maximum possible speed, but remember that to do this you also must use a disc that is rated for this speed or higher.

Archiving files to DVD discs with K3b

The *K3b* application currently provides the best way to burn data DVDs on *madking*. Procedures for archiving files to DVD discs with *K3b* are almost identical to the procedures for creating a data CD, with one exception. Unlike CDRW discs, *re-writable* DVD discs need to be formatted before they can be used. To format a virgin *dvd-rw* or *dvd +rw* disc with *K3b*, select

Tools -> DVD -> FORMAT DVD +/- RW

To create a data DVD:

1) From the main *K3b* menu, select *New Data DVD Project*
If *K3b* is already open and not on the main menu page, select
File -> new project -> New Data DVD Project

2) From the browser pane at the top, drag each file or folder that you wish to archive into the *current Projects* window in the bottom pane. As you add more files to the "project," the total size of the archive will be displayed at the bottom of the window.

3) Give the disc a name by editing the default name in the *Volume name* box in the right center of the *K3b* window.

4) When all of the files and folders you wish to archive are contained in the *Project* window, click on the *Burn* icon. In the *Dvd Project* window that opens, the default value should work fine. If you want *K3b* to verify the integrity of the disc after it has been burned, check the *Verify written data* box as well. (Given the high capacity of DVD discs, this may take several minutes, but verification should be performed for all important discs.) After going through this checklist click on the Burn button and recording will begin.

Currently *burn-proof* technology is not available for DVD burning. Furthermore DVD burning uses a higher throughput rate than CD burning, placing a higher load on system resource. Therefore, be cautious while burning a DVD. Do not play or compile soundfiles or delete large files. Read your email, do some transcendental meditation or go to the bathroom.

5) After burning the DVD, it is a good idea to make sure it can be read by the system. To mount the disc you may first need to eject and reload it. After reassuring yourself that your data really is backed and and recoverable, eject/unmount the disc:

5.5. DVD-Audio

To play back high resolution audio (sampling rates of 88.2, 96 or even — hold on to your hats! — 192 kHz with a 24 bit word size) and to play compositions with four or more audio channels in concerts and on home entertainment systems, there are two alternatives to using a desktop or laptop computer system: *DVD-Audio* (often abbreviated *DVD-A*) and *Super Audio Compact Discs* (abbreviated *SACD*). Standalone DVD-A and SACD playback decks both support high sampling rates, 24 bit word sizes and 5.1 (6 channel) surround sound playback. If connected to a television or computer monitor DVD-A additionally supports onscreen track navigation and transport menus and, for commercially manufactured discs, the

display of still images, brief video or audio/video passages (e.g. interviews), interactive text displays (e.g. liner notes) and similar add-ons and candy that marketers like to call "added value content." (stupid term,don't you think?) Most DVD-Audio players also can play DVD-video discs (e.g. "movies") with surround sound (albeit using Dolby Digital compression, and resulting lower quality audio, which is the standard in DVD-V format). DVD-A players also can play CDs at 44.1kHz 16 bit resolution. However, DVD-A discs, which pack data much more densely on the disc than CDs, require a higher frequency, shorter wavelength laser reader, cannot be read by CD players.

DVD-A and SACD are incompatible formats, and it remains to be seen which, if either, will gain widespread acceptance. (However, there are a few, expensive DVD-A players that also can play SACD discs.) For our purposes, however, there is one overriding advantage of DVD-A format: DVD-A authoring software is available on ECMC Windows system *gesualdo* for creating DVD-A discs; as of this writing no reasonably priced SACD authoring software or burners are available.

Whereas standard DVD-V (video) format divides the disc capacity into a large chunk reserved for video and a much small portion for audio, DVD-A format reverses this allocation, reserving most of the disc space for audio samples on what is called the *AUDIO_TS* directory. This portion of the disc can be copy protected by means of a digital signature and watermark scheme so that no copies can be made from the disc.

DVD-A format also supports a high data transfer rate: 9.6 Mbits (million bits) per second, as opposed to 6.14 Mbits/second with DVD-V format. It turns out that this is not sufficient throughput for six channels of 96 kHz 24 bit samples using standard linear PCM encoding.[5] Six channels of 9624 samples would require a data transfer rate of 13.8 Mb/s. However, an alternative audio encoding scheme called Meridian Lossless Packing, or MLP, also is available within DVD-A format. Encoding audio data in MLP format before it is recorded to a disc "packs" the data more efficiently, reducing its size by as much as 50 % with no loss in audio quality when the signal is decoded by a playback deck. Lossless MLP encoding thus makes it possible to play back six channels of 96k 24 bit samples with a total duration of up to 74 minutes. However, MLP is a proprietary format, developed, copyrighted and licensed (usually at a hefty price) by the Meridian Audio company. Don't look for a GPL version of MLP algorithms anytime soon.

Unlike audio CDs, DVD-A format additionally offers considerable flexibility in audio format within a disc. Different tracks can contain a different number of channels, different sampling rates and different word sizes. Thus, it is possible to include multiple versions of a "song" (or, more interestingly, of your semester project) on a disc for playback on systems with various capabilities — for example a 5.1 9624 version with MLP for systems with 6 speakers, and a stereo version at up to 192 kHz to be used when only a stereo playback system is available. It even is possible to employ different sampling rates and bit depths on different channels within a single track — for example, 9624 resolution for the front channels of a 5.1 surround mix, and 44.1k 16 bit resolution for the two rear surround channels. In this manner commercial DVD-A manufactures (and also ... yes! ... you!) can play around with the trade-off between high audio resolution (which requires more data, filling up a disc more quickly) and total available playing time. A DVD-A disc can hold up to six hours of 44.1k 16 bit stereo audio.

Note that although the DVD-A format basically was designed for recording either 5.1 surround or stereo audio, it is possible to use the six available channels for other multichannel formats. For example, it is possible to record a decoded ambisonic four channel composition onto a DVD-A disc, leaving the center and LFE channels blank. One could also create and burn to a DVD-A disc a work for six full bandwidth channels.

5.5.1. Burning DVD-A discs with discWelder Chrome

The DVD-A authoring program available on Windows machine *gesualdo* is called *discWelder Chrome*, which the ECMC studios have licensed from Minnetonka Audio Software. This is a mid-range, no-frills authoring program without all of the features of wildly expensive DVD-A authoring applications by Sonic Solutions and a few other vendors, but it does have the features we really need. (Would you really want to include an interview with yourself, or pictures of your pet hamster, on a DVD of your semester

[5] Linear PCM (pulse code modulation) encoding is employed in most digital audio systems, including computer soundfile recording and playback and CDs. SACD uses a different, one-bit encoding scheme.

project?) Additionally, the individual channels of multichannel works must first be compressed and encoded before they can be burned to a disc with *discWelder Chrome*.

Burning a DVD-A disc requires more initial planning than burning an audio CD. Certain requirements and limitations must be born in mind as you plan out a DVD-A recording and the preparatory steps that will be necessary before the audio is ready to be burned to a DVD-A disk.

1) *discWelder Chrome* only allows us to import mono and stereo WAVE format soundfiles. If you have a four channel piece, you will need to convert this soundfile to four mono WAVE soundfiles, one for each channel. The ECMC utility *splitchans* can be used on *madking* for this purpose. Paul Coleman also has created a version of *splitchans* for ECMC Windows machines.

2) What sampling rate, bit depth and number of channels will be used for each track ("selection" or composition) on the disc? For 9624 resolution with four or more channels, you not only will need to split the four channels into four mono soundfiles, but also will need to apply MLP encoding to these soundfiles before you import them into *chrome* for burning to a disc. The Windows application *SurCode MLP* is used to create MLP encoded versions of input soundfiles. If you will be burning a stereo track to a DVD-A disc, even at 9624 resolution, MLP encoding is not necessary and should not be used.

   Occasionally you may want to convert two or more channels of a high resolution (9624) multichannel piece to a lower sampling rate and/or a lower bit depth (from a 24 bit source to a 16 bit downsample) in order to avoid the need to apply MLP encoding. To lose as little quality as possible when resampling, however, you need to apply a high quality dithering algorithm during the resampling process. Currently, the best resampling program available in the studios is the application *resample*, also available on *gesualdo*. Useful graphical *help* on using *resample* is available within the application. Be sure to read the section near the end on *dithering* options and procedures.

   Note that the *resample* application can be useful for other purposes as well. For example, if you wish to record a 9624 version of a piece to a DVD-A disc, but also would like to burn a 44.1k 16 bit version to a CD, *resample* can be used to dither down the high resolution master to the CD version.

Useful manuals for *discWelder chrome* and *SurCode MLP* are available in room 52, so I will detail their usage here. You will need to consult these manuals before creating a DVD-A disc.

Assuming you have completed one or more compositions on *madking* and want to burn them to a DVD-A disc on *gesualdo*, it is obvious that a lot of soundfile copying between these two machines will be necessary, and also that you may consume a lot of hard disk space on both machines. Be mindful of this and courteous to other users of these systems. Plan out all of the steps that will be necessary to burn your DVD-A disc in advance, and plan to complete all of these tasks in a concentrated burst of work. Remove soundfiles as soon as they no longer are needed.

Here is a checklist to help guide you through this process of burning a composition created on *madking* to a DVD-A disc on *gesualdo*:

(1) On *madking* : If the composition is stereo, copy the soundfile to your folder on *gesualdo*.
If it is a multichannel work, split the channels into individual mono soundfiles, one for each channel, with *splitchans*, then copy these mono soundfiles to your folder on *gesualdo*.

(2) On *gesualdo* : For multichannel works, you will need to apply MLP encoding to the mono soundfiles. Do this as a batch job with *SurCode MLP*. Then delete the original, unencoded mono soundfiles.
Alternatively, if you want to resample any or all of the source mono soundfiles, do this with the *resample* application. Once this is done, and you have played and are happy with the resampled mono soundfiles, delete the originals from *gesualdo*.

(3) *discWelder chrome* : When all of your source soundfiles are ready for all of the compositions you want to burn to a DVD-A disc, open *chrome*, create a new project and begin assembling this project until it is ready to burn to disc. You also will want to create a navigation menu for the disc.

(4) *discWelder chrome* : Burn the project to a disc. The DVD burner currently installed in *gesualdo* is only capable of burning to *dvd -r* discs at 2x speed. After burning this disc:

(5) Play the completed disc and make sure there are no glitches. Note that 5.1 pieces cannot be played in room 52, which has only four speakers. If your disc is good, burn additional copies with *chrome* if you wish.

(6) Clean up on both *gesualdo* and *madking*. You may wish to archive some or all of the sources used to make this disc, such as MLP encoded or resampled soundfiles and your *chrome* project file, to data CDs or DVDs in case you need to make more DVD-A copies of the disc in the future. Then remove all of the files you have created in order to assemble this DVD-A disc from both *madking* and *gesualdo*. Do it now!

5.6. Creating calibration tones

When you send an electroacoustic composition for inclusion on a concert, it is a good idea to include calibration tones along with the cd or soundfile of your composition. Often, when composers first hear their works played in a large performance space, especially an unfamiliar one, they will be disappointed, and feel that the audio "just doesn't sound quite right." Some of this disappointment is inevitable. While working on the composition in a studio, your ears become very attuned to the acoustical characteristics of the system on which you are assembling the piece, and the room in which you are hearing it. Additionally, amplifiers and loudspeakers must "move a lot more air" in a large concert hall space than in a small studio. There will be more reflections and reverberation, and the large PA speakers that must be used to fill larger spaces generally will not be as accurate as studio nearfield reference monitors. In larger performing spaces, high frequencies — traveling much further and in a more diffuse space— will decay significantly in amplitude before reaching the listener. The large space also may seem to smear details of the work, such as precise panning locations, particularly if the speakers are widely spaced (as is often necessary). I have seen composers agonize during tech sessions of their works (and exasperate audio engineers), requesting that levels be raised or lowered, futzing interminably over EQ settings, trying this, trying that, and in the end winding up little happier than when the tech session began.

In addition to the unavoidable acoustical and psychoacoustical differences between concert hall and studio playback of a piece, even when high quality equipment is used, however, sometimes there actually are technical problems with a concert hall playback system and/or performance space that may be correctable, at least to some degree, if they can be isolated, accurately identified and then treated. The output channels may not be be matched properly in level. Frequency equalization (EQ) circuits in the playback mixer or elsewhere in the system may not be accurate. There may be hiss or noise in the system, or distortion in one or more frequency bands. But how is one to distinguish with any certainly between correctable problems in the playback system and subjective responses that the piece "just doesn't sound as good as it did in the studio?" The answer is to use calibration tones during the tech session.

Calibration tones typically consist of 1 kHz, 10 kHz and 100 Hz sine tones at a known amplitude level played back on all channels of the reproduction system. These tones are long, typically about 30 seconds each in duration, so that there is sufficient time while they are playing to make adjustments in the playback system and to hear the results of these changes.

An ECMC utility called *mkcaltones* enables you to create a soundfile with calibration tones easily for use in such situations.

mkcaltones defaults

will create a stereo 44.1k 16 bit soundfile with three successive sinusoidal tones, the first at 1 kHz, the second at 10 kHz, and the last at 100 hertz. Each tone will have a duration of 15 seconds, and the tones will be separated by one second of silence. The amplitude level will be -15 dB below maxamp, or a raw integer value of about 5623 on a scale of 0 to 32767. (This is the level generally recommended for audio DAT tapes.) In place of the *defaults* argument above, one can include command line flags and arguments that adjust the sampling rate (to any value up to 96000), the bit depth (16, 24 or 32 bits), the number of channels (1, 2, 4, 5, 6 or 8), the duration (any integer value up to 30 seconds) and the gain (values of -3, -6 or even -1 may be more usable than -15 dB with compact disc, DVD and audio soundfile sources.)

The command

mkcaltones sr 96000 bits 24 chan 4 gain -3

will create a calibration tone soundfile at 96 kHz sampling rate, 24 bits, 4 channels and an amplitude of -3 dB relative to maxamp. For more details and examples consult the *mkcaltones man* page.

Note that when you play back these tones on another system, the actual meter levels for the tones may differ from meter readings in room 52, depending upon how much headroom has been calibrated into the playback system gain structure. However, all tones should register at the same level, and remain locked at this level, with no deviations, on all channels.

5.7. The ECMC cd library of sound samples

Over the years ECMC staff members have put together a library of acoustic sound source samples that are available to all ECMC users. We recorded some of these samples ourselves (the Eastman vocal and gamelan sample volumes below) and have licensed others from commercial vendors. You are free to use all of these samples in any way you wish in your compositional work in the studios, but legally you are prohibited from redistributing the commercially licensed samples.

Initially we made these samples available on DAT tapes, but they now are more conveniently available on CDs. As of this writing, our library of acoustic sound samples includes the following cds, most with cd copies:

1. **BBC** : sound effects: (volumes 11-20)	1-26
11: Water	2
12: Birds	5
13: Industry	7
14: Cities	8
15: Rural atmospheres	9
16: Cars	12
17: Sport and leisure	14
18: Bang!	17
19: Electronic (really ugly, yukky samples!)	21
20: Weather	25
2. **McGill** : instrumental samples: (volumes 1-4)	27-85
1: Solo strings, ensemble violin	28
2: Woodwinds & brass	46
3: Piano, percussion, saxes	61
4: Rock percussion, timpani	75
3. **World Colors** : world music sounds: (two volumes)	87-94
volume 1	87
volume 2	91
4. Ancient **Chinese percussion** sounds	95
5. **Chinese strings** (*Pipa* and *Liuqin*)	97
6. Heart of **Africa**	99-??
volume 1	99
volume 2	??
7. Heart of **Asia**	??-??
volume 1	??
volume 2	??
8. Welcome to **Japan** (vol. 2 only)	??
9. Eastman **Vocal samples**	??
10. Eastman **Gamelan samples**	??
11. **Digeridoo and other primitive instruments**	??

Consult the *ECMC AUDIO DAT TAPE LIBRARY* binder, available in all three studios, for a complete listing of the contents of all current sample library cds. Similar information is included in many of the cd jackets.

Over the years we have converted some of the sound sources available on these tapes (especially those recorded at Eastman) into *sflib* soundfiles, but more than 80 % of these sounds are available only on cds or DAT tapes. To sign out a cd, see a staff member. Only two cds can be signed out at a time, and they must be returned within two days. Be very careful with these cds while they are in your possession. It was tedious to produce some of them, and if you lose or damage one, we will have to charge you a replacement fee.

5.8. Using flash drives and external USB drives

Data transfers between optical cd or dvd discs and a computer system are relatively slow, and sometimes are subject to read and write errors and other problems (such as bad discs). During the past couple of years portable external USB 2[6] storage devices have become a very convenient, efficient and economical alternative medium for archiving data and for copying data from one computer system to another (including cross platform transfers between Windows, Linux and Macinstosh computers). Popular current USB storage devices include:

• portable external USB hard drives, about the size of an average hard cover book, with capacities between 120 GB and 1 TB
Portable USB drives are particularly useful for backing up large amounts of data, such as all of the soundfiles used to create one or more electroacoustic compositions, or one or more complete file systems.

• *Flash* drives and similar miniature USB storage devices such as "pen" and "thumb" drives
Lightweight flash drives are about the length and width of a large stick of chewing gum and thus can easily be carried around in a pocket or on a key chain. The drive is enclosed in a plastic or metal case with a USB connector at one end covered by a removable cap. (Be careful. These caps are easily misplaced and lost.) Most current flash drives have a capacity of between 1 and 4 GB and draw their power directly through the USB port on the computer case. Larger flash drives of 6 GB or more are available, but require a supplemental power source and are considerably more expensive.
Flash drives are ideal for daily backup of ascii and project files and also for soundfiles (so long as the storage requirements of the soundfiles does not exceed the capacity of the drive).

• USB "Mini" hard drives, with capacities of 20 or 40 GB also are available. However, these intermediate capacity drives are less frequently used, probably because they cost almost as much as much larger capacity external USB drives.

Most USB external and flash drives come pre-formatted with a single Windows *vfat* data partition. (However, the capacity of many *flash* drives is reduced slightly by a small Windows utility partition called U3.) Linux and Mac system can read and write to the *vfat* partition, but if you are certain that you will use the flash drive exclusively on a Mac or on a Linux box you can reformat it (wipe the drive clean of everything, to start over), install a native Mac or Linux filesystem format and/or, if desired, repartition the drive. Reformatting and/or partitioning might seem hardly worth the trouble with a modest capacity flash drive, although it can solve a possible permissions problem discussed later. However, partitioning often is very useful with large capacity USB external drives.[7]

The procedures for using USB external disks and flash drives are virtually identical. Either before booting or else while the computer is running, connect the drive to a USB port on the computer case with a USB 2 cable (for external hard drives) or with the USB connector on the flash drive. Many flash drives will flash blue when they are connected and are receiving power. External hard drives also need to be powered up.

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[6] For the remainder of this discussion *USB* will always refer to *USB 2* rather than the older, much slower *USB 1* format.

[7] Recommended applications to use for reformatting and partitioning internal and external drives include *gparted* (Gnome Partition Editor) for Linux, the commercial application *Partition Magic* for Windows and the built-in *Disk Utility* on Macs.

Windows, Mac and most Linux systems (currently including *madking*) are configured to continuously poll the USB ports in search of newly connected devices and then to *mount* the device automatically, attaching its folders and files to the current file system. As soon as the device has been mounted, a desktop window for the storage device usually will open, displaying the contents of the drive and thus indicating that the drive is ready for use. If you have created several partitions on an external hard drive, several windows will open, one for each partition. The label of the device or partition will appear in the titlebar of its window.

Some Linux distributions and system administrators prefer to turn off autopolling of USB devices, since this adds to system overhead. In such cases, users must issue commands to mount the drive and subsequently unmount it when it is no longer needed.

To copy files and complete folders to and from the USB drive you can simply drag icons for these files between the window for the drive and a graphical window for some hard disk folder. You also can delete files on the USB drive, rename them, and perform most any action on these files that can be performed on a hard disk file.

These same operations on external disk files also can be performed, sometimes more quickly or with less fuss, by means of commands issued from a shell window. Before you can issue such commands, however, you must know the name and mount point of the drive. In Fedora 7 external disks and storage devices, as well as cd and dvd disks, are mounted on the file system branch */media*. To find out the name of name and path of a mounted flash drive or of external USB disk partitions after the drive has been mounted, type the command

df or, to display the data in "human readable" format, *df -h*

The output of *df* will provide information on the size, current usage and free space on all currently mounted storage devices. Near the bottom of the *df -h* output you should find a line that looks something like this:

Filesyste	Size	Used	Avail	Use	Mounted on
/dev/sdd1	2.0G	1.2	.8G	60	/media/disk

Here a 2 GB flash disk with .8 GB of usable free space has the generic mount point */media/disk*. Sometimes the manufacturer will give the flash drive a fancier name, such as */media/STORE'N'GO*. External USB drives will have a *df* entry for each mounted partition. Now from a shell window we could perform a series of operations like this:

ls -lh /media/disk	[list the contents of the flash disk]
p /media/disk/mix1.wav	[play a soundfile stored on the flash disk]
cd /media/disk	[make the flash drive your current working Unix directory]
*ls *temp**	[list all files on the flash disk whose names include the character string "temp"]
*rm *temp**	[remove all of these "temp" files to free up space on the flash drive]
mkdir Section2	[create a new folder on the flash drive]
cd	[return to your home Unix directory; be sure to perform this command before disconnecting the flash drive]
lsf	[list the soundfiles in your current working soundfile directory]
cpsf flute2.wav perc /media/disk/Section2*	[copy soundfile *flute2.wav* and all soundfiles whose names begin with the character string "perc" to this new folder on the flash drive]

If your flash drive has a volume label name that includes 'special" characters (such as one or more spaces,or a # or ' character), enclose the drive name in double quotes, like this:

ls -lh "*/media/STORE'N'GO"*

p "/media/STORE'N'GO/mix1.wav" (and so on)

When you are done using the flash or external disk drive, be sure first to quit any applications or windows that may be accessing the drive (except for a browser window that displays the contents of the drive), then simply unplug the USB connector of the drive from the USB port on the computer case. The operating system will automatically unmount (disconnect) the drive from the file system and the desktop flash browser window for the drive will disappear. If you type *df* again in a shell the entry for the flash drive will be gone.

5.8.1. Using *rsync* to backup files to external drives

The Unix command *rsync* provides a convenient, time-saving way to archive all of the files in an important Unix or soundfile directory to directories on an external USB or flash drive and to painlessly update these archive directories. Recommended usage is:

rsync -av sourcedirectory targetdirectory

This will synchronize all of the files in the target directory (on the external USB or flash drive) with those in the source directory, so that the target directory mirrors the source directory, but may also include some older files that have subsequently been deleted from the source directory on a system hard drive. If you issue the alternative command

rsync -av --delete sourcedirectory targetdirectory

the target directory will be an exact clone of the source directory. Files that currently exist in the target directory, but no longer exist in the source directory, will be deleted from the target directory. See the *rsync man* page for more options.

Example usage of *rsync*:

I am working on an electroacoustic composition. I keep all of the ascii and other source files used to create this composition (e.g. *score11* files, PD patches and so on) in a Unix directory named *Project* (/home/allan/Project), and I keep all of the soundfiles for this project in an *snd* disk directory also named *Project* (/snd/allan/Project). I have an external USB drive, or a flash drive, with the volume label name */media/disk*. On this external drive I want to create a folder named *Backup*, where I want to back up all of the source files in /home/allan/Project, and another folder on the external drive named *Sounds*, where I want to archive all of the soundfiles currently in /snd/allan/Project. To accomplish this, I could issue the commands

rsync -av /home/allan/Project/ /media/disk/Backup/

rsync -av /snd/allan/Project/ /media/disk/Sounds/

These two commands will copy all of the files in */home/allan/Project/* to */media/disk/Backup/*, and all of the files in */snd/allan/Project/* to */media/disk/Sounds/*. Note the concluding / ("slash") characters at the ends of both the source directories and the target directories. Be sure to include these trailing slash characters at the ends of all source and target directories or *rsync* will not work as you intend.

Caveat: If your external USB or flash drive is formatted with the default Windows *vfat* format, *rsync* may give you errors such as

chgrp "/media/disk/." failed: Operation not permitted

The *vfat* filesystem has no read-write permissions for "other" users, and thus cannot save these permissions in its version of a file. The actual contents of the files copied, however, should be identical to the original version on the hard disk.

At the conclusion of my next work session on this project, I could again issues these two *rsync* commands, and the contents of */media/disk/Backup/* and */media/disk/Sounds/* will be updated to include all new files I have created for this project during today's work session. Files in a source directory that I have edited or otherwise changed will be updated in the archive directory.

If I want to delete files on the external backup drive that no longer exist in the source directories, so that my archive folders are exact clones of the current source directories, I could include the *--delete* flag option:

rsync -av --delete /home/allan/Project/ /media/disk/Backup/
rsync -av --delete /snd/allan/Project/ /media/disk/Sounds/

If I have a Linux or Macintosh system at home I also can use my external USB or flash drive and *rsync* to create mirrors of some of my important folders on *madking* on my home system.[8]

Since I will be using these two commands frequently — possibly at the conclusion of every work session on the project — I would like to simplify their execution. Here are two ways to do this:

☞ Method (1)

• Create a file with that includes the two *rsync* lines above. I will name this file "backupproject."

[8] In fact, by using *ssh* and *rsync* in combination, it is possible to mirror folders on two remote systems without the need for a USB external or flash drive.

- Mark the file executable: *chmod +x backupproject*
- In the future, I need only type *./backupproject* to execute these two commands.

If, over time, you create several utility shell scripts like this one, create a subdirectory named *bin* branching from your home folder and place all of your executable scripts in this *bin* folder, which your shell automatically will search when interpreting your commands. In this case you will only need to type *backupproject* to execute the two rsync commands.

☞ Method 2:
I could edit the file *.bashrc* in my home directory and include a (long) line like this:

function backup { (rsync -av /home/allan/Project/ /media/disk/Backup/ ; rsync -av /snd/allan/Project/ /media/disk/Sounds/) }

Here again, in the future, I will only need to type *backupproject* to execute the two commands.