Towards an Integrated Media Transfer Environment:

A Comparative Summary of Available Transfer Tools and Recommendations for the Development of a Toolset for the Preservation of Complex Digital Objects

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ABSTRACT

Efficient media transfer is a difficult challenge facing digital preservationists, without a centralized service for strategy and tools advice. Issues include creating a transfer and ingest system adaptable enough to deal with different hardware and software requirements, accessing external registries to help generate accurate and appropriate metadata, and dealing with DRM. Each of these is made more difficult when dealing with complex digital objects such as computer games or digital art. This paper presents the findings of several studies performed within the KEEP project, where numerous open-source and commercial media transfer tools have been evaluated for their effectiveness in generating image files to be integrated into an emulation-based preservation solution for complex digital objects. We provide suggestions for assembling toolsets based on the specifications of these tools, therefore providing a valuable source of information for media transfer activities.

Categories and Subject Descriptors

H.3.4 [**Systems and Software**]: Performance evaluation (efficiency and effectiveness).

H.3.7 [**Digital Libraries**]: Systems issues.

General Terms

Documentation, Performance.

Keywords

Digital Preservation, Image File, Transfer Tools, Optical Media, Magnetic Media, Digital Objects, Emulation.

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1. INTRODUCTION

The continuous development of digital storage media in recent decades has caused serious problems for accessing digital data stored on deprecated media carriers [1]. As media carriers cease to be supported by computer manufacturers and therefore become obsolete, the data stored on them need to be transferred to supported storage media in order to remain accessible. This problem is greatly amplified in libraries and other memory institutions, where a large number of materials are stored digitally [2].

Media transfer gives rise to numerous challenges. Issues include creating a transfer and ingest system adaptable enough to deal with different hardware and software requirements [3], accessing external registries to assist with the generation of accurate and appropriate metadata, and dealing with Digital Rights Management [4].

In this context, the main findings of different studies carried out as part of the KEEP project[1] (European Commission, ICT-231954) are gathered and presented. One of the main outcomes of KEEP is a media Transfer Tool Framework (TTF)[2] designed to support intelligent and robust transfer of complex digital objects within a preservation workflow. Although KEEP is focused on emulation-based preservation strategies the TTF is equally applicable to a migration-based approach.

A pre-requisite for building the TTF was to assess available open-source and commercial transfer tools with a view to incorporating them in the framework. Transfer tools for both magnetic (3.5'' and 5.25'' floppy disks) and optical (CDs and DVDs) media

[1] The KEEP project is co-financed by the European Union's Seventh Framework Programme for research and development. For further information on KEEP see: http://www.keep-project.eu

[2] http://www.keep-project.eu/ezpub2/index.php?/eng/Work-packages/WP1-Transfer-tool

carriers were examined. The choice of these media carriers was determined by the scope of the KEEP project. Effectiveness in generating computer game images ready for integration into an emulation-based preservation solution was the main criterion for our analysis.

In the following sections a concise analysis of tools for magnetic media and optical media is provided. For each of these tools an outline of their software and hardware requirements is given, together with their reading configuration settings and image generation capabilities. A general overview together with a presentation of the test outcomes completes the analysis. A conclusive summary of the analysis performed is then offered, together with a set of recommendations for anyone intending to assemble toolsets based on the specifications and testing of these analyzed tools.

2. EVALUATION OF TRANSFER TOOLS FOR MAGNETIC MEDIA CARRIERS

This section presents the analysis of three transfer tools for magnetic media carriers. The list includes two commercial transfer tools, Disk2FDI and Catweasel, and a freeware open source transfer tool application named Nibtools. The tests on Disk2FDI were conducted with the assistance of its creator (and KEEP technical lead) Vincent Joguin whose specialist knowledge and experience helped produce optimal tool performance. No qualified expert assistance was provided during the test on Catweasel and Nibtools. This together with the use of sector-dumped formats which are less able to capture protections or custom formats may have been contributory factors in the higher failure rate noted for these two magnetic media transfer tools.

A total of 2268 floppy discs of 3.5'' or 5.25'' size were tested in the evaluation study of Disk2FDI. As Table 1 shows, the environments of these floppy discs varied and included the following: Amiga, Apple II, Apple IIGS, Apple Macintosh, Archimedes, Atari ST, BBC Micro and C64. The following emulators were used to determine the success of the reading process of the Amiga, Archimedes, Atari ST, BBC Micro, C64 and Apple-based floppy disks respectively: WinUAE[3], Arculator[4], Hatari[5], B-EM[6], Hoxs64[7] and CiderPress[8].

The evaluation study on the Catweasel and Nibtools transfer tools (see Table 1) was based on the reading process of the same set of floppy disks. Nine and seven floppy disks containing video games for the Amiga and C64 computers respectively were used for the Catweasel transfer tools. Due to inability to read image files from Amiga, only the seven floppy disks containing C64 video games were tested on Nibtools. In order to determine the success of the reading process of Amiga floppy disks the WinUAE emulator was used to render the produced image files. The Hoxs64 and CCS64[9] emulators were used instead for testing the image files generated by C64 floppy disks.

[3] http://www.winuae.net

[4] http://b-em.bbcmicro.com/arculator

[5] http://hatari.berlios.de

[6] http://b-em.bbcmicro.com

[7] http://www.hoxs64.net

[8] http://ciderpress.sourceforge.net

[9] http://www.ccs64.com

2.1 Disk2FDI

Disk2FDI[10] is a commercial tool produced by Vincent Joguin primarily for generating Formatted Disk Image (FDI) files from floppy disks. In addition to the Formatted Disk Image format, Disk2FDI provides support for the following formats: Amiga Disk File, Commodore 1541, Macintosh DiskCopy 4.2, Apple II DOS-Ordered, IBM FM (single density), IBM MFM (PC and many others), and Atari ST Disk Image. The main features of Disk2FDI require a custom, but very simple, 2-wire Disk2FDI cable.

The FDI format is able to represent precisely information stored on a floppy disk, including possible copy protections and non-standard disk layouts. This accuracy of data representation is achieved by capturing at a very low level the magnetic flux transitions on the floppy disk surface. Disk2FDI captures the signals emanated by the electric pulses as soon as these are generated by the floppy disk drive from the magnetic surface of the disk, and before they are further processed by the floppy disk controller.

FDI files are currently supported by the following programs: WinUAE and E-UAE (Amiga emulators), CiderPress (Apple 2 disk image management tool), B-Em (BBC Micro emulator), Arculator (Acorn Archimedes emulator) and Hoxs64 (Commodore 64 emulator). The complete specification of the FDI image file format is open and available as a text file (FDISPEC.TXT) within the Disk2FDI distribution archive (including the freely-downloadable trial version).

2.1.1 Requirements and Specifications

Disk2FDI requires a pure DOS operating system (including FreeDOS), and a DOS-accessible mass-storage device large enough to contain image files. Further requirements include: any processor from the Pentium family or any other faster processor, 32 MB (min.) RAM, a parallel port configured for DOS (ideally from a PCI parallel port card), a Disk2FDI cable, and a floppy disk drive attached to the motherboard (not through a USB interface).

2.1.2 Test Results

Out of the 2268 transferred discs tested only a single protected floppy disc from the Amiga family was found to be imaged incorrectly by Disk2FDI. The remaining floppy discs were read successfully and as result fully working FDI image files were produced.

The tests showed that the average reading time for an FDI image is approximately eleven seconds for each track, typically resulting in transfer times in the range of one hour per disk. Although FDI files are compressed using lossless algorithms, they are generally very large. For example a 3.5'' 1.44 MB floppy disk produces a 14 MB FDI file.

2.2 Catweasel

Catweasel[11] is a commercial floppy disk controller that provides access to a large variety of floppy disk formats thus enabling its users to perform a range of different tasks such as reading, writing and erasing contents of floppy disks. Catweasel uses a PCI card which communicates directly with the floppy disk drive.

[10] http://www.oldskool.org/disk2fdi

[11] http://www.jschoenfeld.com/products/catweasel_e.htm

Table 1. Results obtained from the tests performed on transfer tools for magnetic media.

System	Discs read	Environment	Format	Working images	Defective images	Success Rate
Disk2FDI	2268	Amiga	FDI	1486	1	99.95%
		Apple II	FDI	51	0	
		Apple IIGS	FDI	9	0	
		Apple Macintosh	FDI	11	0	
		Archimedes	FDI	48	0	
		Atari ST	FDI	492	0	
		BBC Micro	FDI	24	0	
		C64	FDI	146	0	
Catweasel	16	C64	D64	4	3	31.25%
		Amiga	ADF	1	8	
Nibtools	7	C64	G64	4	3	57.14%

In addition to the PCI card, the Catweasel manufacturer, Individual Computers, provides drivers for the Windows 2000, Windows XP, Linux and Amiga OS4 operating systems and an application named *Imagetool*[12] in order to perform a variety of tasks (i.e., writing, reading and erasing) on the floppy disk. Jumpers together with the necessary cables to attach the card to one of the floppy disk drivers and to the on-board floppy disk controller are also provided.

The process of capturing the magnetic flux transitions on the floppy disk surface takes place at a low level: the tool acts as a flexible floppy disk controller by directly reading (but also writing in this case) signals from (and to) the floppy disk drive. Catweasel also makes use of sophisticated algorithms to provide automatic error corrections of stream of pulses which are found off-center in corrupted or sensitive floppy disks.

Catweasel supports by default a wide range of disk formats from the 3.5'' and 5.25'' families such as Atari, Apple II, Apple Macintosh, MS-DOS and different Commodore disk drive series (Leighton 2008). Further disk formats can be handled by downloading drivers from the Internet and reprogramming the PCI card.

2.2.1 Requirements and Specifications

Catweasel requires a Windows (98SE, ME, 2000 or XP) or any Linux or Amiga operating systems. Any floppy disk drive (usually the 3.5'' and 5.25'' disk drives) required to support the desired disk formats previously mentioned can be used. The only floppy drives which are currently known to be incompatible with Catweasel are from the Mitsumi D359 series, Teacdrives with integrated flashcard reader, Citizen drives for Compaq computers and the Samsung SFD-321B. A maximum of two floppy disk drives can be attached simultaneously to this disk controller.

If the computer already has a floppy disk drive and an on-board floppy disk controller, the PCI card (to be inserted in a PCI bus slot) provided by Individual Computers can be attached directly to the floppy disk drive on one side and to the on-board floppy disk controller on the other side using the cables provided. In the absence of an on-board floppy disk controller, the communication between this and the PCI card can be ignored. If the drives are for 5.25'' or 8'' floppy disks, special adapters will be needed for attaching these drives to the PCI card.

Once the Catweasel card is attached and the driver installed, reading/writing operations can be performed via Imagetool. Catweasel offers three different types of sector-dumped images to choose from: *plain image file*, *d64 (with error info)* and *atr*. However, Catweasel does not provide a disk imaging facility to an accurate and generic format (such as the FDI format).

If the *plain image file* option is selected and the *Read Disk* button is clicked, Catweasel will generate a plain image file of the specified disk. The extension of the image file depends upon the specific floppy disk format. If the *d64 (with error info)* option is selected, Catweasel will generate an extended D64 image file providing sectors error information in addition to disk content. The selection of the *atr* option instead will produce an Atari disk image file.

2.2.2 Test Results

A test set of sixteen floppy disks containing Commodore64 (5.25'') or Amiga (3.5'') video games were used with Catweasel during the testing process. As it can be seen from Table 1, Catweasel read only five disks correctly, thus producing image files which could be accessed via the previosuly mentioned emulators. The remaining eleven floppy disks instead led to the generation of image files which could not be rendered correctly.

During our experiments the average time needed to generate an Amiga disk file with Catweasel was 60 seconds. Based on its official Webpage of this tool 50 seconds is required to read a 3.5'' Amiga 1760 kB floppy disk and to generate an image file from it.

2.3 Nibtools

Nibtools[13] is a free open source program for PCs for generating image files, modifying the formats of these image files and writing content to floppy disks from a defined set of CBM64 floppy disk drives. We consider the source data processed by Nibtools less accurate than the source data produced by Disk2FDi and Catweasel, as the capture of the magnetic flux on the floppy

[12] http://siliconsonic.de/t/catweasel-usermanual.pdf

[13] http://c64preservation.com/nibtools

disk surface in this tool takes place at a higher level: while Catweasel captures and processes directly the signal generated by the electric pulses from the disk drive, Nibtools captures and processes the generated stream of bits only after the original signal has been processed digitally to the GCR (Group Code Recording) format by the floppy disk controller. However, Nibtools is able to create more accurate images (to the CBM-specific G64 format) than the Catweasel software. Nibtools supports only two CBM64-related image files: G64 and D64.

2.3.1 Requirements and Specifications

Nibtools requires a Windows (NT, 2000, XP, Vista or 7), any Linux or a MS/DR/Caldera DOS (with CWSDPMI) operating system. Under Windows or Linux, OpenCBM 0.4.2 (or any other higher version) should be used. Nibtools requires a Commodore 64 floppy disk drive from the 1541, 1541 II or 1571 series. A XP1541 or a XP1571 parallel cable with a serial cable from the x-series (X1541, XE1541, XA1541 or XM1541) or a XEP1541, XAP1541, or XMP1541 combination cable are also required.

The CBM64 floppy disk drive needs to be attached to a parallel port of the PC using a suitable parallel and serial cable. A combination of cables can be used otherwise, although the use of parallel port add-ons for the floppy disk drive is preferred in order to achieve higher communication speed. In addition to these physical cables, the OpenCBM kernel device driver will be needed in Windows or Linux in order to permit connection between the floppy disk and the computer[14].

Reading and writing tasks in Nibtools are performed in a command line interface. Once the floppy disk drive has been connected, the command *nibread [options] filename.nib* will generate a NIB image file. An extensive range of options is available, including choices for specifying the floppy disk drive unit or the starting and ending track of the floppy disk or for performing (crude) reading verifications.

Once the NIB image file has been generated the command *nibconv filename.nib filename.yy* can be used to convert the NIB file into an image file of a format specified by the file extension in *filename.yy*. The file can be converted to a G64 image file or a D64 image file.

2.3.2 Test Results

Out of the seven floppy disks containing Commodore64 video games only four floppy disks were read correctly producing image files which could be accessed correctly via fully working emulators. The remaining three floppy disks generated image files which could not be rendered correctly.

The tests performed as part of the KEEP Project suggests an average of sixty seconds to generate a C64 disk image files.

3. EVALUATION OF TRANSFER TOOLS FOR OPTICAL MEDIA CARRIERS

The section presents the analysis of five transfer tools for optical media carriers. We tested four commercial transfer tools: Alcohol 120%, Daemon Tools, CloneCD and Blindwrite. Additionally we examined a free program transfer tool application named ImgBurn. Thirteen CDs or DVDs containing video games for the Windows 95/98, Windows 3.1 or the DOS environment were used (see Table 2) for each of the aforementioned transfer tools. The four discs used for Windows 95/98 had copy protection schemes of different types (TOC, ProtectCD VOB and SecuRom). In order to determine the success of the reading process of these discs the DOSBox[15] emulator was used to render the image files of the video games for the DOS and Windows 3.1 environment. A computer with Windows 95 environment was instead used for testing the produced image files of video games for Windows 95/98 environment.

3.1 Alcohol 120%

Alcohol 120%[16] is a commercial application for optical disc authoring and disk image emulation providing image file generation capabilities from CDs and DVDs. Alcohol 120% provides support for a wide range of CD (CD-DA, CD+G, CD-ROM, CD-XA, VideoCD, Photo CD) and DVD (DVD-ROM, DVD-Video, DVD-Audio) formats. One of the most interesting features of Alcohol 120% is the ability to bypass several copy protection schemes, such as SafeDisk, SecuROM and Data Position Measurement (DPM) and to create image files of PlayStation and PlayStation 2 file systems. Due to legal issues Alcohol 120% does not generate image files from DVDs with CSS protection.

3.1.1 Requirements and Specifications

In order to run Alcohol 120% any Intel/AMD-based PC with a Windows (2000, XP, Server 2003 or Vista) operating system is required. At least 32MB of RAM and 10GB of free hard disk space, one or more CD-ROM or DVD-ROM drives and one or more CD/DVD recorders are also needed. If more than 2 CD recorders are installed, 700MHz CPU and 128MB RAM are recommended. A CD/DVD recorder can be used as a reader if there is sufficient hard disk space to store a whole CD/DVD image.

In order to communicate with the required hardware devices Alcohol 120% uses the SPTD (SCSI Pass-Through Direct) device driver. Alcohol will be able to use any disk drive no matter what type of hardware interface is used to connect the peripheral device with the computer.

Depending on the type of disk inserted, Alcohol 120% provides a wide list of different data types including NormalCD, NormalDVD, PlayStation 2, SafeDisk and SecuROM. Alcohol 120% provides context-sensitive image file formats to choose from, such as Media Descriptor, CloneCD, CDRWin and Standard ISO, depending on the image data type selected. Users can configure the reading process by accessing options such as Skip Reading Errors, Fast Skip Errors Block, Advanced Sector Scanning, Reading Sub-channel Data from Current Disk and DPM; this last option is used for reading CD/DVDs with DPM protection mechanism. Alcohol 120% can read this mechanism and encode it into a Recordable Media Physical Signature (RMPS), which reproduces the effects of a DPM. The RMPS and other metadata of the original disk are then stored in a Media Descriptor (MDS) file.

If the image format option for the image file is set to a *Media Descriptor Image*, Alcohol 120% generates an MDF file (the Alcohol 120%'s proprietary disk image format) which includes the actual data on the disk, and a Media Descriptor Image file, containing the information related to the header and track of the disk.

[14] http://c64preservation.com/files/nibtools/readme.txt

[15] http://www.dosbox.com

[16] http://www.alcohol-soft.com

Table 2. Results obtained from the tests performed on transfer tools for optical media.

System	Discs read	Environment	Format	Working images	Defective images	Success Rate
Alcohol120%	13	Windows 95/98	MDS	3	1	92.3%
		Windows 3.1	ISO	3	0	
		DOS	MDS/ISO	6	0	
DaemonTools	13	Windows 95/98	MDS	1	3	76.92%
		Windows 3.1	ISO	3	0	
		DOS	MDS/ISO	6	0	
CloneCD	13	Windows 95/98	CCD	2	2	84.61%
		Windows 3.1	ISO	3	0	
		DOS	ISO	6	0	
Blindwrite	13	Windows 95/98	B6T	3	1	92.3%
		Windows 3.1	ISO	3	0	
		DOS	B6T/ISO	6	0	
ImgBurn	13	Windows 95/98	ISO	0	4	69.23%
		Windows 3.1	ISO	3	0	
		DOS	ISO	6	0	

If the image format option for the image file is set to a *CloneCD Image File* Alcohol 120% will create an IMG file containing the data on the disk, a SubChannel Data file which stores the sub-channel data from all the tracks of the disk and finally a CloneCD Image file, which contains information associated with the logical structure of the disk.

If the image format option for the image file instead is set to a *CDRWin File*, Alcohol 120% will generate a BIN file containing the data on the disk and the CDRWin file containing track information. The selection of the *ISO Image File* option will cause Alcohol 120% to create a single ISO file containing the entire data content of the disk.

3.1.2 Test Results

All but one of the 13 test discs was read correctly and fully working MDS or ISO image files were created as result. The CD protected with the VOB ProtectCD produced an MDS image file which could not be accessed via emulation.

Reading speed configuration options are available only for CDs but not for DVDs. The maximum reading speed available during the image creation process for a CD was 24x (around 3.600 MB/sec), although the highest reading speed recorded with this optical medium was 12x (1.848 MB/sec). The highest reading speed recorded with a DVD instead was 11.2x (15.512 MB/sec).

3.2 Daemon Tools

Daemon Tools[17] is a commercial optical disc authoring and disk image application offering image file creation from disks inserted in CD, DVD, HD-DVD and Blu-ray drives, in addition to other related functionalities such as burning, converting and editing image files and erasing disk content.

[17] http://www.daemon-tools.cc/eng/products/dtproAdv

3.2.1 Requirements and Specifications

In order to run Daemon Tools a Windows (2000, XP, 2003, Vista or 7) operating system is required. A minimum of 500 MHz CPU, 256 MB of RAM is also required, in addition to one or more CD-ROM or DVD-ROM drive.

Daemon Tools uses the SPTD (SCSI Pass-Through Direct) device driver to access the required hardware devices. Daemon Tools can be used with any disk drive, regardless of the hardware interface used to connect the drive with the computer.

Irrespective of the nature of the CD or DVD, the following output file formats can be chosen: *MDS/MDF*, *MDX* and *ISO*. Depending on the image file format chosen and on the data type selected, Daemon Tools provides a list of additional settings for configuring the reading process. This includes settings for choosing a desired Data Position Measurement reading speed, for choosing the number of times the application can retry reading a specific disk sector if it is damaged and ignore any faulty sector found during the reading process. Daemon Tools also provides a list of configuration settings related to the generated image. This includes settings for reducing the size of the generated image file and for securing the generated file via a password-based security mechanism.

If the image format option is set to *MDS/MDF* two distinct files will be created: an MDF file, which includes the actual data of the disk, and a Media Descriptor Image file which contains the set of information related to the header and tracks of the disk. If the image format option instead is set to *MDX* an Extended Media Descriptor file, together with a MDF file and the Media Descriptor Image file previously mentioned will be generated. If the image format option instead is set to *Standard ISO* a single ISO file containing the entire content of the disk will be generated.

3.2.2 Test Results

In the test three copy-protected CDs resulted in defective image files which could not be accessed via emulation. The remaining ten discs were read correctly and fully working ISO or MDS image files were generated.

Reading speeds for both CDs and DVDs are customizable. The maximum reading speed available for a CD is 24.0x (3600 KB/sec), while the maximum reading speed for a DVD is 8.0x (10820 KB/sec).

3.3 CloneCD

CloneCD[18] is a commercial optical disc authoring application which can create image files from CDs or DVDs. CloneCD can read CD-R, CD-RW, DVD, Multisession and Digital Audio (CD-DA) disks. CloneCD provides support for DVD split file image formats, in addition to ISO and UDF formats. It also bypasses the SafeDisk 3 protection scheme during the reading stage.

3.3.1 Requirements and Specifications

In order to run CloneCD a Windows (98, ME, 2000, XP, Vista or 7 of 32 or 64 bit) operating system is required. An IBM-compatible personal computer with a 500 MHz Pentium microprocessor or higher, at least 64 MB of RAM is also needed.

CloneCD makes use of Elby CDIO, a novel device driver developed by Elby, the manufacturer company of this disk authoring tool. The widespread ASPI (Advanced SCSI Programming Interface) interface is not supported by this program though. Any disk drive, regardless of the hardware interface used to communicate with the computer, can be used with this authoring application.

CloneCD does not offer any choice of data formats for the image file to be generated. For CDs, CloneCD provides the following profiles for selection: Audio CD, Data CD, Game CD, Multimedia Audio CD and Protected CD Game. If the disk inserted is a DVD, the application offers only the DVD profile.

If the disk inserted is a CD the application will generate three files: an IMG file which contains the actual data of the disk, a Channel Data file containing the sub-channel data from all the tracks of the disk and a CloneCD Image file containing information of the logical structure of the disk. If the disk inserted is a DVD two distinct files will be created instead in the folder specified: a DVD file which includes the raw data of the DVD disk and a single ISO file containing the data content of the disk.

3.3.2 Test Results

Of the thirteen discs used during the testing process eleven discs were read correctly and fully working image files were generated by these discs. The remaining two copy-protected discs (ProtectCD VOB and SecuRom) led to the generation of image files which could not be rendered via emulation services.

CloneCD does not provide a configurable reading speed. The maximum reading speed recorded for a CD was 11.99x (2110 KB/sec). The maximum reading speed recorded for a DVD was 5.02x (6777 KB/sec).

3.4 Blindwrite

Blindwrite[19] is a commercial authoring program that allows image files to be created from CD, DVD and Blu-Ray disks. Blindwrite handles every available CD format, most of the DVD formats (DVD-R, DVD+R, DVD-RW, DVD+RW, DVD-RAM, DVD+R Double Layer and DVD-R Dual Layer) and Blu-ray formats (BD-R and BD-RE). Disks for game consoles such as Xbox, Wii and Playstation are also supported.

3.4.1 Requirements and Specifications

In order to run this authoring tool the Windows (XP, Vista or 7) operating system is required. Blindwrite needs an Intel Pentium III or an AMD Athlon or any higher processor. At least 512 MB of RAM with Windows XP or 1 GB of RAM with Windows Vista and 4.3 GB of available hard disk space are also required.

Blindwrite uses the Patin-Couffin CD device driver in order to provide access to CD, DVD and Blu-ray drivers. Any disk drive can be used with this tool, regardless of the hardware interface used to connect the peripheral device with the computer.

Blindwrite offers eight profiles to choose from: *Automatic*, *Audio CD*, *Audio CD+G*, *Bad Sectors* (for detecting automatically bad sectors in the disk), *ISO Image*, *No Split*, *Normal* and *Nibble*.

Regardless of the type of disk inserted, Blindwrite will generate the two following types of files, unless the ISO profile has been selected: a Blindwrite 6 Track Information file, a file type associated primarily with this application, which contains information of the tracks, and a Blindwrite 6 Disk Image file, which contains the actual data of the disk. If the ISO profile has been selected, an ISO file will be created along with the previously mentioned Blindwrite 6 Track Information file.

3.4.2 Test Results

During the testing phase a single CD with the ProtectCD VOB V.5 protection scheme led to the creation of an image file which could not be emulated. The remaining twelve discs were read correctly and fully working B6T, B5T or ISO image files from these discs were produced.

Blindwrite provides configurable reading speed. The maximum reading speed provided is 48x (7 MB/sec) for CDs, 16x (21.6MB/sec) for DVDs and 8x (36 MB/sec) for Blu-ray disks. The reading speed during the image generation however could not be evaluated as no information was provided by the application.

3.5 ImgBurn

ImgBurn[20] is a free authoring program for CDs, DVDs and Blu-ray disks providing image generation from disks and from files on the host computer or on a network, in addition to image writing and full disk readability verification. The main drawback with this program is the inability to read sub-channel data from a CD. ImgBurn does not provide support for multi-session disks and raw disks for disk burning activities.

3.5.1 Requirements and Specifications

ImgBurn requires a Windows (95, 98, Me, NT4, 2000, XP, 2003, Vista, 7 or 2008 R2) operating system. ImgBurn also supports Wine[21], thus allowing users to run this application on Unix-like operating systems. A 1.7 GHz Pentium IV processor or higher and at least 512 MB of RAM is also needed to run this authoring tool.

[18] http://www.slysoft.com/en/clonecd.html

[19] http://www.vso-software.fr/products/Blindwrite/blindwrite.php

[20] http://www.imgburn.com

[21] http://www.winehq.org

ImgBurn supports the following device drivers in order to access the external disk drives: ASPI (WNASPI32.DLL), ASAPI (ASAPI.DLL), SCSI Pass Through Interface, ElbyCDIO and Patin-Couffin. ImgBurn will work with any type of disk drive, regardless of the hardware interface used.

Independent of the type of disk ImgBurn provides the user with the following list of file formats to choose from: Bin Files, IMG Files and ISO Files. A list of configuration settings related to the image reading process is also provided. Settings include editing the maximum size limit of the generated image file, configuring the reading modality of the inserted disk, setting the number of retries after the reading failure of a disk sector and skipping the disk sectors that can't be read.

If the image to be generated is a BIN file and the inserted disk is a CD ImgBurn will generate an IMG file, a CDRWin file containing the information of the disk header and tracks and a CloneCD Image file, if this has been selected in the Settings section of the program. If, in this context, the user has decided to not generate any layout image files, ImgBurn will create a BIN file and a CDRWin file. If the inserted disk is a DVD, the program will create a BIN file including the actual data on the disk in addition to DVD and/or Media Descriptor Image layout files, provided that these have been selected in the Settings section. If the image to be generated is an IMG file and the inserted disk is a CD, two files will be created: an IMG file containing the entire content of the disk and a CDRWin file containing the information of the disk header and tracks. If the inserted disk is a DVD, an Image file will be generated, in addition to a DVD and/or Media Descriptor Image layout files, provided these two files have been selected in the Settings section. If the inserted disk is a CD and the desired format of the image to be generated is an ISO file ImgBurn will create a BIN file and a CDRWin file. If the inserted disk is a DVD instead an IMG file will be generated, in addition to a DVD and/or Media Descriptor Image layout files, only if these two files have been selected in the Settings section.

3.5.2 Test Results

Nine discs, all without copy-protection schemes were read correctly and working ISO image files which could be rendered via emulation were generated. The remaining four discs, all including different protection schemes (TOC, ProtectCD VOB and SecuRom) proved unsuccessful in creating working image files.

The maximum reading speed provided by ImgBurn is 56x (8.624 MB/sec) for CDs, 56x (77.56 MB/sec) for DVDs and 56x (252 MB/sec) for Blu-ray disks. During the image generation process the maximum reading speed recorded however was 12x (1.848 Mb/sec) for a CD and 12x (16.62 MB/sec) for a DVD.

4. SUMMARY AND CONCLUSIONS

Media transfer presents a number of technical challenges when dealing with complex objects such as computer games. However, tools are available and developers have a vested interest in ensuring their applications are accessible even to casual users.

The results of the performed tests on the magnetic media transfer tools have shown that the complexity of the process increases sharply and that a relatively high degree of expertise is required to get the best out of the tools. Certain output formats such as FDI have been found to be more capable of handling non-standard or protected disks. Catweasel supports a wide range of media, but during the test its performance was relatively poor, as less than half the tested items were effectively captured. In contrast, the free application NibTools performed better, even if the source data processed, as previously mentioned, was technically less accurate. Disk2FDI has demonstrated to be the most robust of the three, trading off a significant increase in transfer time for a level of detail and accuracy that far surpasses the other tools. The question in this context perhaps is where preservationists would rather invest their time: how much time they would take to capture an image, or how long they may potentially have to spend re-capturing an image using multiple means. Overall, the performance gap between free tools and commercial ones in these tests was minimal. Furthermore, the open source nature of NibTools implies a surrounding community which could provide in the future testing and optimization for this tool, in addition to open access APIs for more technical users, thus enabling this application to be integrated potentially within any framework. For the purposes of KEEP, this is naturally highly advantageous. For memory organizations the capture of magnetic media probably requires investment in a more stable and powerful transfer tool such as Disk2FDI.

Regarding the optical transfer tools tested it can be said that all of these were relatively easy to set-up and to operate. No significant difference in terms of disk reading time was found among these transfer tools. ImageBurn has proven to be reasonably effective with older Windows and PC formats and it can be considered a good starting point. Of the commercial tools, Blindwrite offers perhaps the best combination of robustness and flexibility – its ability to manage console game discs is highly advantageous compared to the others (though it should be noted that tests were not carried out with such discs). Certainly, Clone CD and Alcohol120% have a similar level of robustness and also offer some copyright protection scheme circumvention, probably best suited for older discs.

As far as optical media is concerned, the biggest technical issue is handling copy protection schemes. This might be a serious issue for those attempting to preserve with complex commercial objects such as games. In these cases, a viable solution would be non-technical: close collaboration with industry, lobbying for the importance of preservation and the collection of not just disc images but source code. For example, in 1997, id Software released the source code of the classic game DOOM freely, along with pre-release alpha and beta versions of the game. This brought direct advantages to the company: they were able to use community ports (Boom to MBF to prBOOM)[22] as the basis of the source code for a new mobile version. This is a case study that preservationists can use in the argument for the advantages of releasing of older code. In addition to this, it makes the game a preservationist's dream. There is no question that preserving access to source code remains the primary goal of preservationists working with complex digital objects.

Our investigation has shown that even start-up preservation projects with limited resources can have access to reasonably robust tools - one of which has the distinct advantage of being open source - capable of basic media transfer operations. We recommend using BlindWrite for the transfer of information from optical media, and Disk2FDI for the transfer of information from magnetic media. All of these aforementioned tools should be used in conjunction with file characterization software such as

[22] http://www.idsoftware.com/iphone-doom-classic-progress

DROID[23] or JHOVE[24] in order to identify the produced image files.

In terms of integration within a single framework, access to APIs and source code of tools is a fundamental requirement if tools are to be packaged to a single application. KEEP's intention is to link distinct applications into a common framework that sits alongside existing tools, creating a supportive workflow management environment. Following from this initial study, we are now in a position to integrate the recommended tools within this environment for further testing, which will be reported in due course.

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