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Contents

Chapter 16
Multimedia technologies

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During the last decade, there have been endless and dramatic technological changes in all three major areas of information technology – computing, communications and content. We have witnessed the advent of personal computers, worldwide packet networks, optical disk and other mass storage media, interactive video technology, image technology, digitizing and scanning technology, computer graphic technology, and the growth in both size and number of massive public and private databases – bibliographic first, then numeric, and now multimedia. These three major areas were rather disparate in earlier years. Now, they are becoming integrated and quite international in scope and impact. There is every reason to believe that this situation will continue at an even faster pace. Now, the world is going digital, and there is no turning back.

Background and history

The concept of mixed media or multimedia has been around for some time, the form and its impact having been registered well before the advent of the computer, personal or otherwise. Though many people even today think of the computer mainly as a number-cruncher, early visionaries like Vannevar Bush already saw its future role as an information and media processing powerhouse in the 1940s. In his famous 'As We May Think', published in the July 1945 issue of *Atlantic Monthly*, Bush (1945) advocated mechanizing scientific literature by association with a device called 'memex'.

Bush's idea endured and inspired two people about twenty years later – Douglas C. Englebart of the Stanford Research Institute and Ted Nelson of Xanadu. Englebart, influenced by Bush's vision, developed a system for knowledge workers, called NLS (oNLine System) in 1963, which embodied many original ideas and concepts of hypertext, including windows, the mouse, electronic mail, and a hypertext-like ability to link and annotate documents. Nelson coined the word 'hypertext' in the

1960s, which he described as non-sequential reading and writing that links different nodes of the text.

Hypertext and hypermedia/multimedia

Hypertext mimics the brain's ability to access information quickly and intuitively by reference. At the basic level, a hypertext system is a database management system which permits one to connect screens of information using associative links, and by allowing users to link information together, thereby creating trails through associated materials.

At the more sophisticated level, a hypertext system has a software environment which supports collaborative work, communication and knowledge acquisition. When the system's database structure is complex, it is common to supply a special node called a graphical browser which displays the structure of the database and serves to re-orient users who are dislocated.

Hypertext is the forerunner of multimedia/hypermedia. Although the concept of hypertext has been with us since the 1940s, it was brought down to the 'household' level only after the introduction of Apple's HyperCard in late 1987. Using HyperCard, one can create links in a given work – an electronic book, multimedia presentation or anything that might best be explored in a non-linear way. Then, when users are reading or exploring, they can click on icons to zoom to related topics which may be in the same file or in another one.

Hypermedia extend the hypertext concept to link textual material to all forms of material – graphics, image, video, animation and sound – that may be digitally encoded for storage and retrieval through computer-based systems. As early as 1988, Casa-Bianca (1988), in his attempt to publish a hypertext-like journal, *Hyper-Media*, graphically presents a typological framework of hypermedia in what he calls HyperMedia Map. He uses graphic icons, as shown in Figure 1, to illustrate how the world's communications media – audio, audiovisual, film, music, video – have been incorporated with comput-

ers, communication networks, publishing and information resources, 3-D graphics, design and system management to enable us to provide multimedia/hypermedia information in a new, global, 'wired society'.

Clearly, multimedia technologies are not one single technology, and there is no single product, or definable market. The term 'multimedia technologies' epitomizes technology integration through the use of multimedia tools.

In order to summarize the above and facilitate our discussion on multimedia, a simple working definition of multimedia is proposed as follows.

Multimedia extends the hypertext concept of non-linear and non-sequential links of textual material to all forms of material that may be digitally encoded for storage and retrieval through computer-based systems, including images, sound, graphics and animation . . . Thus, multimedia refers to a synthesis of text, data, graphics, animation, optical storage, image processing and sound. Clearly, multimedia technology is not a single technology, and

Fig. 1. HyperMedia Map.

Computers	Publishing	Audio	Music
Audiovisual	Film	Video	3-D Graphics
Interactivity	Communications	Management	AEC

there is no single product, or definable market. It epitomizes technology integration.

Multimedia tools and technology

Input and output technologies: hardware and software for digital data, sound, image, video and films

As librarians and libraries everywhere are still handling largely printed materials, it is important to understand that the information seekers are no longer satisfied with only printed materials. They will want to supplement the printed information with more dynamic sound, music, graphics, animation, photography and video, all of which can now be fed into an ordinary computer where they can be cut, changed, shaped, combined, manipulated, enhanced and reconstructed into all kinds of exciting information products. In order to benefit from the current multimedia environment, one needs to know the multimedia tools available in the market-place so that they can be used to bring multimedia to the desktop.

Hardware and software for users of multimedia

Currently the market-place is full of multimedia products, as shown by the thousands of titles included in any directory of multimedia titles, many of which are multimedia CD-ROM titles. For libraries' interest, multimedia products of every reference type, as well as subject topics, are available. Because more and more products have incorporated rather large numbers of images, sound and digital videos, much more powerful hardware than the bare minimum requirement for a PC system will be required:

- 80386 CPU.
- EGA/VGA or VGA A Plus Graphics.
- 2 MB RAM.
- Double-speed CD-ROM Drive.
- Microsoft Windows 3.1.

The general rule is that whenever possible, try to acquire a system with as much speed, hard disk space

and RAM as possible. For example, some products will run properly only with a 486 or Pentium processor with at least 16 MB of RAM and a four-speed CD-ROM drive. The unfortunate fact is that most multimedia application products are developed for users with the higher-end systems, and few have kept the low-end systems users in mind.

Multimedia production tools

Only a couple of years ago, producing multimedia applications was generally difficult, since most multimedia production tools were either not readily available or simply too expensive for general use. But fast technological development has made it possible for many to consider producing their own multimedia applications now. To facilitate librarians' use of these tools for production purposes, those for both Macintosh and PC systems are included below. Although Macintosh tools are often preferred for the development of multimedia applications, they might not be readily available to libraries in developing and less developed countries.

There are simply too many multimedia production tools to cover all adequately. For example, for the Macintosh platform alone, the *Macintosh Multimedia & Product Registry* (1995) lists on forty-five pages over 700 tools in every possible category of production work. A similar publication including tools for the PC platform is IBM's yearly issue, *Multimedia Today: The Sourcebook for Multimedia*. The issue for 1995 lists over 600 production tools. For illustrative purposes, the following discussion covers only a very small number of selective tools in some distinctive categories.[1]

1. Price information will be indicated by ranges of list prices for 1996. Although products can generally be obtained at lower cost from computer warehouses, list prices represent better the prices for countries outside the United States. The ranges are: L for up to US$299, M between US$300 and US$699, and H for more than US$700.

Animation

The best known animation tool is Macromedia's Director 4.0 (H) which is available for both Mac and Windows (Fig. 2 shows a screen from version 3.1). Macromedia's Director is a powerful animation and authoring tool. Users can create, combine and synchronize graphics, text and animation with audio and video; add full interactivity with buttons and scripts; export and import QuickTime movies, etc. Conversion software is also available to convert Mac Director applications to PC and vice versa. Other notable software includes Adobe's Premier 4.1 (H), Avid's VideoShop 3.0 (M) for Mac, and Gold Disk's Animation Works Interactive 2.0 (L) for PC.

Clip art and photography

In this category, Photo-CD technology has been utilized fully by most producers to store about 100 images of clip art and photographs on almost every subject for both Mac and PC platforms (some store 600 when the top two levels of higher-resolution images are sacrificed). Of international interest, Educorp's International Graphics Library is a CD with 32-bit QuickDraw images (L). These clip art images can be copied and pasted on multimedia applications. More clip art CDs can be found in various software catalogues from Image Club in Milwaukee (United States).

Development tools

The market-place has over fifty development tools for multimedia authoring and digital publishing. For Macintosh, the most noteworthy is HyperCard (L) (current version is 2.3). It features an intuitive interface designed to guide users through the construction of hypermedia programs and presentations of various media elements such as pictures, paint graphics, QuickTime movies, audio, videodisk sequences

Fig. 2. Macromedia's Director 3.1.
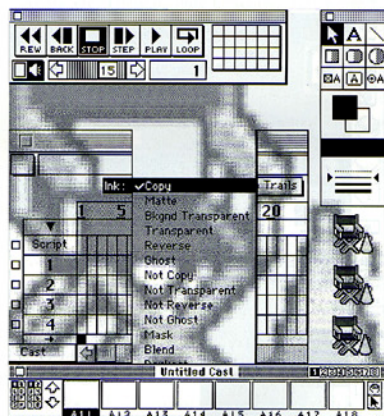
and text, where users want them simply and quickly. Other popular ones include Macromedia's Authorware 3.0 (H) (Fig. 3) for both Mac and Windows, the Voyager Co.'s Expanded Book Toolkit (L) and SuperCard 3.0 (M). Other PC systems include Aim Tech's IconAuthor (H) and Motion Works' MediaShop (M) and ToolBook (M).

Drawing and painting

Most noteworthy in the drawing and painting category are Adobe Illustrator 5.5 (M) (Fig. 4), Canvas 3.5 (M), Macromedia's Freehand 5.0 (M), Claris' MacPaint 2.0 (M), and Adobe's SuperPaint 3.5 (M). All are powerful illustration and design tools that simplify the creation, manipulation and refinement of artwork with advanced features for editing, text handling, colour support and more.

Fig. 3. Macromedia's Authorware Professional.

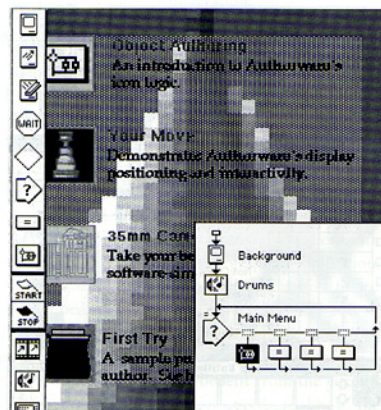

Fig. 4. Adobe Illustrator.

Image processing

Adobe's Photoshop (M) for both platforms (Photoshop 3.0.3 for Mac) (Fig. 5) is the most recognized and most powerful image processing tool. It lets users design artwork with a wealth of powerful painting and selection tools, or retouch and correct true colour or black and white scanned images with image editing tools and filters. It also has a wide range of third-party plug-ins for enhanced image manipulation, most notably Kai's Power Tools 2.1 (L), which provides a set of three dozen powerful extension and filter plug-ins that expand the ability to create computer-generated artwork and manipulate scanned images. Aldus PhotoStyler 2.0 (M) for Windows is also a popular tool for PCs.

Media catalogues

A number of tools are available for organizing and quickly retrieving digital photos in categories.
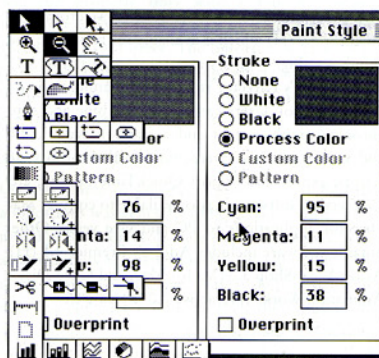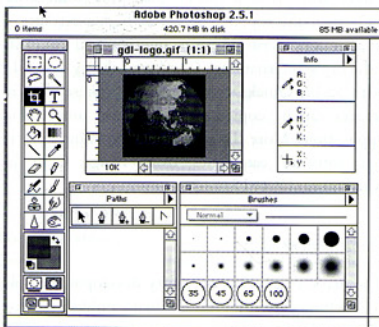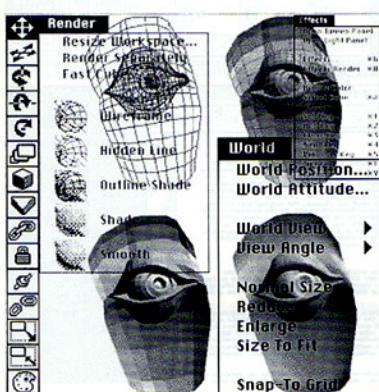
Fig. 5. Adobe's Photoshop 2.5.1.

Adobe's Fetch 1.2 (L), Inspace System's Kudo Image Browser (L) and Kodak's Showbox (L) fall into this category for Mac, while Electronic Imagery's Image-

Fig. 6. Macromedia's Swivel 3D Professional 2.0.4.

Manager (L) and Lenel Systems' Media Organizer (L) are for PC users.

Modelling and rendering

Numerous powerful tools are available in the market-place for creating photo-realistic computer images and animation at an affordable price (under US$1,000) for the type of sophisticated work that was possible only with mainframe and minicomputers a few years ago. Some powerful tools are Specular International's Infini-D 3.0 (M), Strata Inc's Strata Virtual (L) for real-time renderer, Macromedia's Swivel 3D Professional 2.0.4 (M) (Fig. 6) and Virtus Corp.'s Virtus VR (L). Tools from Strata and Virtus are for both Mac and PC systems.

Music software

Music is an important element of a multimedia production. Various tools are available as a MIDI (Musical Interface for Digital Instruments) sequencer, editor and performance tool that provides

multitrack recording, precise editing of all musical events, etc. These include Unicorn's Performer 5.02 (M) and Opcode Systems' Vision 2.0 (M) for Mac, Midisoft's Studio (M) for Windows and Turtle Beach System's Wave for Windows (M) for PCs. Digi-Design's SoundTool (M) consists of a sound accelerator card and Sound Designer II (software) which allow hours of CD-quality sound to be recorded on to a hard drive and edited with unparalleled precision.

Optical character recognition

For multimedia applications, there is a great need for text materials as well. Thus, it is important to have effective tools to be able to turn hard-copy printed texts into digital word-processing files. Optical character recognition (OCR) software is very useful for this process. An outstanding example is Caere's OmniPage Professional (M) (Fig. 7), which is an advanced OCR solution to turn printed texts into word processing files. It is available for both Mac and PC. Another competitive OCR software is Windows is Xerox's TextBridge Pro 96 (M).

Presentation and video-editing software

Many high-powered software tools are available for on-screen animation presentations with motion, sound and QuickTime, and flexible non-linear editing systems for Mac. For presentation purposes, Gold Disk's Astound and Adobe's Persuasion 3.0 (M) are powerful graphic and digital video software that will produce or deliver data-intensive multimedia presentations. Macromedia's Director 4.0 (H), Adobe's Premier 4.1 (H), and Avid's VideoShop 3.0 (M) are powerful tools providing an economic means of professional video editing. Director and Premier are available for both Mac and PC systems. Other PC desktop presentations include Motion Works CameraMan (L), Eduquest's Linkway 2.01 (L) and Linkway Live! (L), Lenel Systems' MultiMedia Works (L), and IBM's Storyboard Live! 2.0 (L).

Fig. 7. Caere's OmniPage Professional.
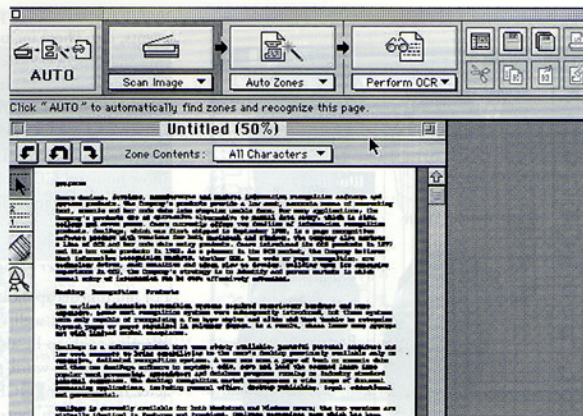
Special effects

Like clip art and photographs for fast and easy use of still images, there are many clip media products available for immediate use of ready digital videos, such as Macromedia's ClipMedia (M) with professional animation, sounds and videos arranged on CD-ROMs in various subject categories (education, business, medicine, etc.). Many products, like Olduvai Corp's Sound Clips 1.0 (L), feature an average of 100 sounds per volume.

In addition, software tools are available for producing special effects for multimedia production. One of the most used is Gryphon's Morph 2.5 (L) for Mac, which smoothly transforms one image into another with dynamic morphing. Gallery Effect 1.51 (M) is another tool that transforms scanned photographs and other bit-mapped images into works of art. The counterpart of Griffin's Morph (L) for PC is North Coast Software's PhotoMorph 2 (L), which allows users to combine and apply sophisticated special effects to bit-map images and AVI video clips, with features for desktop video, including motion morphing.

Multimedia peripherals

Multimedia requires hardware and software power and speed as well as special capabilities to capture sound, image and video. Thus, peripheral devices which can accelerate any process as well as performing any of the capturing functions are essential. In addition, because all multimedia elements will consume a large quantity of memory and storage space, there will be a need to look into those peripherals that can double memory as well as compress and decompress multimedia files. The following are samples of peripherals which are worthy of serious consideration.

Accelerators

Many accelerators and chargers, such as DayStar Digital's Image 040 (H), can accelerate imaging functions up to 600%. Unfortunately these boards are generally quite expensive (over US$1,000) and are intended for high-end operations.

Audio/video controllers

IBM's M-Motion Video Adapter/A (H) for PS/2 can receive and process analogue signals from multiple external video and audio sources, and then send them to a monitor and external speakers for immediate viewing/listening in multimedia application settings. In this way, a PC can be connected directly to an analogue videodisk device and grab the analogue videos directly to integrate into multimedia applications. The Creative Labs' Sound Blaster 16 boards for PCs provide rich CD-quality stereo sound for multimedia, education, business, home and entertainment applications at affordable prices.

Digital cameras

In the last two years, several reasonably priced high-performance digital cameras have been introduced. Apple, Canon, Kodak and others have produced such digital image capture devices at a cost ranging from $350 to over $1,000. Users should acquire cameras only after studying carefully their need for digital images. These digital cameras can be connected to hardware systems using any platform. Most digital cameras function like regular cameras and therefore are mainly for capturing individual images. Another type of digital camera which can capture both colour pictures and videos is becoming quite popular. Examples include VideoLab's FlexCam (L) and Connectix's QuickCam (L). These are compatible with all leading video digitizing boards. Each is an integrated colour camera and microphone and can produce video output in both NTSC and PAL.

Digitizers and frame grabbers

In addition to software, built-in hardware capabilities or addition digitizers and frame grabbers (generally these are additional peripheral boards) are required for real-time digitizing of sound, images and video. For example, Macromedia's MacRecorder Sound System (previously marketed by Farallon) includes both the digital sound recorder hardware and SoundEdit software for users to record, edit and play back live or pre-recorded sounds on a Macintosh. Digital frame and video grabbers are abundant in the market-place. For example, Radius' SpigotPower AV (M) provides full-screen, full-motion capture and playback of interlaced and non-interlaced JPEG video. It is able to capture and save full 24-bit colour data. Creative Labs' Video Blaster boards of different models can bring full-motion video sequences to a PC. Users can capture analogue video sequences at up to thirty frames per second. Generally one connects the television video recorder, and/or video camera to these boards.

Scanners

Scanners are essential for turning hard-copy texts, pictures in both positive and negative forms and films into digital files. Because of these different original formats, there are also different types of scanners. These include:

- Flat-bed scanners, such as Microtek's ScanMaker II (M) and III (H) models, that convert printed and artwork to digital files. For example, the ScanMaker III (H) is a 36-bit colour high-resolution flat-bed scanner up to 1,200 dpi. Generally, a scanner with at least 300 dpi can be quite effective for multimedia application development. Although more expensive and higher resolution drum scanners are also available, they are generally too expensive (some are over $35,000) for general-purpose use.
- Slide scanners that will do the same with photographs, such as Microtek's ScanMaker 1850S (M).
- Film scanners, such as Microtek's ScanMaker 35t (H), that can scan any 35 mm slide in 24-bit colour mode in up to 16.7 million colours or in 8-bit grey-scale mode to capture up to 256 shades of grey.

- Hand-held scanners (L) that generally provide a low-cost alternative for producing digital images for multimedia applications. However, the resolution of these scanned images is low and the images can easily be distorted.

Need for mass storage in information work (archives, library and information services)

Library, information and archival work generally deals with very large quantities of information. Regardless of whether information sources are in printed or electronic formats, space is always a key issue. Mass storage is required to meet:

- The need for a large-volume digital storage system for archival management.
- The need to provide users with immediate access to the rapidly growing volume of data and information that is stored in digital information systems and is likely to be distributed on optical media in the future.
- The need to provide users with access to multimedia information quickly and interactively through the integration of technologies.
- The need to transfer a large volume of data and/or files from one system to another.

The following will discuss briefly the technologies available for mass storage and the types of storage media as well as the drives available for using these media.

Various technologies available for mass storage

Traditionally libraries have used conventional media like film, microfilm and microfiche to store information materials, but they are bulky and rather expensive. With the advent of computer and optical technologies, mass storage has shifted mostly to electronic media. There are several different technologies available for mass storage on magnetic tapes, high-density floppy disks, portable hard disks with a

capacity of over 2 GB, and optical disks. But it is optical media that are the primary ones for mass storage. Because of this, the following section will explore further the different types of optical media.

Storage media: optical disks, CD-ROM, etc.

The various types of optical media offer different storage densities, media formats, transfer rates, capabilities and compatibility among commercial vendors' products. In the last decade alone, a flood of new media and applications – CD-ROM, laser videodisks, write-once and read-many devices, erasable disks, to name just a few – have been introduced, promoted and utilized. There is a wide range of optical alternatives available to provide the highest application flexibility to end-users.

Figure 8, modified from a figure from Chen (1989), shows that optical media can be grouped into three major categories:

- Read-only media.
- Write-once and read-many.
- Erasable.

Under each of these major categories, a multitude of optical storage media can be found. For more detailed information on each of these optical media, see Chen (1989). All of them are essential for multimedia application developments.

Drive and interface

Each different kind of optical media requires an appropriate drive to be connected to a microcomputer system.

Videodisk players

Multimedia CD-ROMs have become popular products in recent years. Earlier, interactive videodisks were the popular means of presenting multimedia applications. Even today, some applications still choose videodisks as end products if quantities of still and moving images are large. For example, one side of a videodisk can store 58,000 still images and

Fig. 8. Types of optical media.

- Videodisks
  - Analogue videodisk (58,000 images/side and 30 minutes of 2-track sound)
  - Digital videodisk (600 MB)
- Read-only media — Compact disks
  - CD-audio (600 MB)
  - CD-ROM (600 MB)
  - CD-interactive (600 MB)
  - CD-interactive video (600 MB)
  - CD-video (600 MB)
  - DVI (600 MB)
  - DVD (2 GB)
  - Photo-CD (600 MB, i.e. around 100 images of 5 levels of resolution)
  - Multimedia CD (600 MB)
  - Optical card (from 2 MB upwards)
  - Optical film (600 MB)
  - Optical tape (varied)
- Optical media
  - Writable media
    - Write-once read-many
      - WORM (from 200 MB upwards)
      - CD-recordable (600 MB)
      - Optical card (from 2 MB upwards)
      - Digital paper (variable)
    - Erasable disc
      - (ranging from 100 MB to 2 GB)

thirty minutes of video in dual sound tracks. These are huge in comparison to what can be stored digitally on a multimedia CD-ROM even with high-ratio compression. For the latter, we are talking about a few hundred digital images and less than twenty minutes of digital video in small windows. Thus, videodisk disk applications are still substantial. The major manufacturers of videodisk players are Philips, Pioneer and Sony. Each has produced several different models – industrial or general models with different playing speeds, and some with the capability of playing both NTSC (National Television System Committee) and PAL (Phase Alternation Line) disks.

CD-ROM drives

The CD-ROM drive is currently the most popular device; it can be used to play regular CD-ROMs (mostly text-based) and Photo-CDs as well as multimedia CD-ROMs. Speed is one of the most significant considerations when acquiring such a drive. In order to run a multimedia CD-ROM, the minimum requirement is a double-speed (2X) drive. However, 4-speed and even 6-speed are available in the market-place. The 4-speed drive is very affordable and can be purchased for less then US$200 per unit in the United States.

CD recorders

WORM and erasable drives are essential for mass storage, publishing and back-up of multimedia development materials. Earlier WORM drives played discs generally holding 100 MB to 200 MB of data. The latest WORM CD medium is CD-R (CD-Recordable) which can store 600 MB of data and requires a CD recorder with appropriate software to record information on the disc according to the appropriate CD standard. For example, JVC's Personal RomMaker, Kodak's PCD Writer and Philips' CDD 522 Compact Disc Recorder are only a few samples of such CD recording devices with hardware and software solutions that allow users to

premaster and master their own CD-ROMs in-house on the desktop for both PC and Mac platforms. Optical Media's TOPiX is a CD publishing system used to record information on CD. Once the information is recorded, the disc will be used in the same manner as any other CD-ROM by using a regular CD-ROM drive. It goes without saying that for multimedia application development, such CD recording devices are most useful!

Erasable drives

For multimedia work, no matter how big the size of the hard drive, one will quickly run out of storage space. Thus every multimedia product developer has some kind of device that can expand the hard drive's capacity substantially. Such devices are also used to back up the materials on the hard drive. An erasable medium is very attractive for this purpose as it can be modified and/or re-used. However, erasable optical disk technology is still not very stable, and both the medium and the drive are quite expensive. An erasable drive can cost over US$2,000. Thus, one of the more popular products has been the SyQuest drive; each SyQuest cartridge can store from 44 MB to about 200 MB of data/information.

Two of the hottest products in this line now are Iomega's Zip and Zap drives, which are both easy to use and affordable. The Zip drive, which runs with its Zip disk (100 MB per disk) costs only a meagre $199 per drive and the disk is less than $20, depending on the quantity purchased (over ten will cost only $14.99 per disk). The Zap drive, with a disk capacity as big as 1 GB, costs only around $599. Because of this incredible offer, many personal computer manufacturers have decided to include a Zip drive as part of the regular system configuration.

Multimedia operating and file system
Multimedia hardware and peripherals

To enter the interactive multimedia world, a minimum equipment configuration should be more than

the bare minimum described earlier. It should consist of the following components:

- A computer system with a minimum of 4 MB of RAM.
- A 350 MB hard disk drive.
- A 14.4 kbps modem (fax modem would be preferable).
- A double-speed CD-ROM drive.
- A portable videotape recorder.
- A fixed videotape recorder capable of being connected to a computer output either directly or through an appropriate AV card inserted into one of the bus slots in the computer.
- A television monitor for use during taping and playback.
- A scanner.

Additional hardware in the form of an LCD display panel or LCD projection system is highly recommended.

Multimedia software

The minimum software configuration for *using* multimedia products is rather low, since most products have plug-and-play capabilities with very few requirements other than the installation processes. However, the following are varying levels of software requirements for *producing* simple multimedia applications:

- A basic editing software package, such as those available from Adobe, Avid, Radius and others.
- An intermediate-level software system that would include all of the above plus a free-standing audio editing software package, a two-dimensional modelling or rendering software package and a graphic/titling package such as Adobe Photoshop.
- An advanced-level software system that would include all the above plus an advanced-level three-dimensional modelling or rendering software package, and an authorware package for

output to hard, floppy disk or to read/write compact disc.

Costs and equipment/software

The equipment cost varies greatly from one model to another, and from one configuration to another. Thus it is best to check with the vendors for current price information. However, it is safe to estimate that a PC Pentium multimedia system can be acquired from US$1,500 to $4,000, and a Macintosh Power Mac from US$2,000 to $5,500, depending on the system model, RAM size, hard disk size, and connected peripherals. Whenever possible, efforts should be made to acquire a system with as large a RAM and hard disk storage capacity as possible.

The cost of software also varies greatly, ranging from less than $100 to over $1,000. However, powerful software like Adobe Photoshop costs about $600 and Macromedia's Director about $900.

Creating multimedia applications

The abundant multimedia tools are to be used for creating multimedia applications. Yet how one goes about developing multimedia depends on the nature of the application and how it will be viewed and used. Although there is no multimedia development formula, the process does follow a series of basic steps (Jerram and Gosney, 1993, p. 29). These steps include:

- Concept.
- Content and interface.
- Product.

It is impossible in a short paper like this to cover every aspect of the process, but each major step, and the subsets within each step, are clearly indicated in Figure 9.

Planning and design (including data preparation and processing)

Planning and design is always the most important component of any development, regardless of whether

images often need to be processed and enhanced by the use of software like Adobe Photoshop.

Video. Using the video-capturing software via a video-capturing board, one can convert video sources from television, video recorder and video camera to digital video and save them in popular formats such as QuickTime movies (in both platforms), or AVI (Audio-Video Interleaved) for PC applications. The standard for digital video is MPEG (Moving Pictures Experts Group). Again, liked the scanned images, captured digital videos will have to be edited by the use of software tools like Macromedia's Director, Adobe's Premier or Avid's VideoShop.

Sound. Through the use of sound recording software and a sound recorder, sound sources from tapes, cassettes and video can be converted to digital sound files, which can also be manipulated and enhanced by means of existing tools, some of them described earlier in this paper.

Data compression for digitized data, sound and fixed and moving images

Non-text files consume a large amount of storage space (for example, one colour image at screen resolution can easily take up about 1 MB of disk space or more); thus the issue of size becomes very significant, and hence compression and decompression.

Compression is a widely employed technique to reduce the size of large files without appreciably changing the way a viewer sees the images or digital videos or hears the sounds. Once compressed, the file must be decompressed before it can be used. Compression and decompression can be accomplished by software alone or through the use of a combination of software and hardware. Take image as an example: compression software analyses an image and finds ways to store the same amount of . information using less storage space. Compression hardware usually consists of a ROM chip with built-

in compression routines for faster operation, or a co-processor chip that shares the computing load with the computer's main processor.

There are different levels of software compression:

- Lossless compression: no information lost through the compression process. In this way, the file size is generally not reduced much.
- Lossy compression: through the compression, some information is lost. This will reduce the file size more dramatically than the lossless one.

The most common method for compressing image is called JPEG, which is a standard way of reducing image file size that discards information which could not be detected easily by the human eye. In compressing the digital video, the standard is MPEG. MPEG is an industry standard for moving images that uses interframe compression (or frame differencing) as well as compression within frames. There are different MPEG standards, such as MPEG I, which optimizes for data rates in the 1 to 1.5 MB/sec range (the common transfer rate of CD-ROM drives and T-1 communications links), and MPEG II, which optimizes for data rates above the 5 MB/sec rate (specifically for broadcast video applications).

Interactivity in multimedia technologies

There are many compelling reasons for using multimedia for education, training, information delivery, business, entertainment, etc. First of all, the power of pictures is enormous. Only recently, with the advent of multimedia technologies, have we been able to tap the undeniable power of visual images and other non-textual information sources.

But equally appealing for multimedia technology is the power of interactivity – a concept extended from hypertext as discussed in the introductory section. Through the ages, information has been presented and absorbed in a linear fashion. Interactive multimedia brings the incredible freedom to explore a subject area with fast links to related topics.

Distribution, storage and use of digital data and documents

Portability

Mass storage and storage media were discussed above. Currently, most digital data have been stored on optical media such as CD-ROMs, CD-Rs, and Photo-CDs, and most interactive multimedia products are produced and distributed as multimedia CD-ROMs, or interactive laser disks. The portability of these products, specifically those on CD-ROMs, is great.

When multimedia applications are stored or published on an optical medium such as CD-ROM, they can be distributed easily for intra-organizational use. For a few copies, in-house CD-R technology can be used to produce the CD-ROMs. When published formally, whether commercially or not, the CD-ROMs or laser disks will be mastered by companies like 3M, DMI, Philips, etc. The cost of production generally is around US$1,000 to $1,500, with an additional cost for each unit ranging from $1.50 to over $10 depending on the quantity of the order.

Commercially produced CD-ROMs are generally published and distributed much like books, and they will be properly packaged with an attractive graphically designed cover, and publicized for sale either directly from the publisher or via distributors, or both. Currently over 10,000 multimedia products have been published.

Use and re-use of stored documents

When information source materials are in digital form and stored electronically on a digital medium, they can be used and re-used for any suitable purpose. They can be retrieved easily to answer an information inquiry, used to create multimedia applications, or used for resource-sharing in either a network environment or for electronic publishing

on the Internet or the World Wide Web. The important thing is being digital!

Long-term conservation of electronic data

We are very much aware of the need to back up electronic data with additional copies of floppy disks, backup tapes, Zip or Zap disks, or CD-Rs. It is important to add that optical media, specifically something like CD-ROM, tend to give an impression that they are the ultimate conservation medium with no possibility of data loss. Actually this is not the case. There are reports on the lifetime of optical media such as CD-ROM, suggesting thirty years or more. However, it is difficult to verify the accuracy of these predictions at this time. All electronic media have the possibility of wearing out, and thus it is important to make duplicate copies in order to avoid data loss due to wear and tear. Optical media such as CD-ROMs and laser disks should be used carefully to prevent possible scratches on the surface. Non-optical electronic media, such as magnetic tape and floppy disks, should be stored under proper temperature and humidity control.

As for the storage of the source materials, it is important to continue finding the best ways to preserve and conserve them regardless of whether they are electronic or not. Most images and videos originally came from film or microfilm sources. These should be kept using the best conservation methods, since electronic image-capturing – still or moving – cannot currently produce images of as high a resolution as those on films and microfilms. Thus, as technologies advance, there will be need still to re-use the source materials in order to produce new images of higher resolution (see Chapters 14, 24 and 25).

Emerging technologies and future trends

As the use of multimedia will continue to expand, it is fair to expect that more tools in every category outlined earlier will be introduced with more func-

tionalities and at lower cost. Thus, creating multi-media applications will be easier as time goes on.

With the explosive development and use of the Internet and the World Wide Web, and the exponential growth in use of Web browsers like Netscape, we are witnessing the exciting marriage of multimedia and the Internet/World Wide Web in a way never possible before (see Chapter 18). Instead of Web publishing with mainly still images, graphics and text, now virtual reality and Web publishing with avitars are being introduced by all major companies like Netscape and Microsoft. The forthcoming versions of Web browsers, like the 3.0 version of Netscape, are filled with all kinds of features and

capabilities to present digital videos, sound, animations, etc., as shown in Figure 10.

In addition to the increasing capability to include all types of multimedia publishing on the Web, emerging technologies will enable exciting live multimedia Internet publishing as well as real-time fast delivery of multimedia broadcasting onto the desktop. A good example of live multimedia Internet publishing is the '24 Hours in Cyberspace' event on 8 February 1996 (Arnold, 1996). On that day, Rick Smolan, producer of award-winning multimedia products such as *From Alice to Ocean* and *Passage to Vietnam*, pulled off the most ambitious Internet event ever undertaken by deploying hundreds of

Fig. 11. The homepage of Global Digital Libraries (accessing the Louvre web site).

Fig. 10. Advanced multimedia capabilities of Netscape Navigator 3.0.

photographers and journalists around the world to electronically transmit stories, images, videos and audio annotations onto a live, one-day Web site. In total, sixty-three photo-illustrated articles from every part of the world were electronically published for global access within twenty-four hours. The event demonstrated the immense power of a new medium that goes far beyond the scope of television news, magazines, radio or newspapers.

Clearly this big-time project involved hundreds of millions of dollars and offers us a glimpse of where the future of multimedia and Internet/World Wide Web are heading. But what about the immediate future for libraries? The prospect is equally excit-
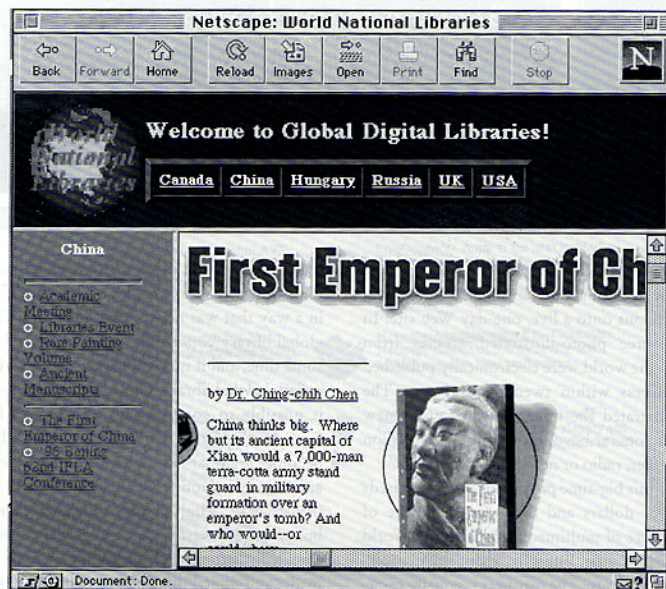
ing. It is clear that more than ever, libraries around the world will be able to share information resources in a way that was never possible before. The digital global library concept has been advocated for quite some time, and it is possible now for us to have such a digital global library. Global communication makes it possible to connect national libraries from different part of the world. These national libraries become regional 'knowledge centres' which can access information from the entire global 'network of networks'. High-density optical storage in jukeboxes makes a vast increase in global collection size possible. Cutting-edge technologies such as multimedia and digital imaging are available in this high-

speed global network so that texts, images and even voices can be transmitted from one part of the world to another. At the same time, however, nationalism becomes a stronger theme: building national collections, serving as an information source for national government, and collecting national history or culture are of concern now more than ever. The use of multimedia and Knowledge Navigator permit the delivery of this information, as well as information from other countries, to citizens' homes, schools and offices. In this kind of environment, printed information sources, such as books, journals and archival materials, meet a highly competitive technology.

Digital information sources become essential (Chen, 1994). The enormous possibilities for combining multimedia and the Internet/World Wide Web together have also been demonstrated. Figure 11 shows how one is able, at the click of an icon, to jump to any national library or other major library in a given country instantly (Knauth, 1996). Access can also be gained to information on the award-winning multimedia product, *The First Emperor of China* (see Figure 12).

As long as the resources are in digital format – regardless of whether they are still images, video or sound – and are on a Web server, one can obtain this information almost instantly from anywhere in the world. A graphic directory of over thirty national library homepages around the world can be found in Chen (1996). This is an exciting time! ∎

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Fig. 12. Accessing information on *The First Emperor of China* through the Global Digital Libraries Web site.

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