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Zagazig University
Faculty of Computers and Informatics

Multimedia Information Systems and Digital Library

Information System Department
Fourth Year-Second Term
[2017/2018]

Multimedia Information Systems and Digital Library

[IS 460]

The course contents has been collected and arranged by:

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بسم الله الرحمن الرحيم

﴿ قُلْ إِنَّ صَلَاتِي وَنُسُكِي وَمَحْيَايَ وَمَمَاتِي لِلَّهِ
رَبِّ الْعَالَمِينَ ﴿١٦٢﴾ لَا شَرِيكَ لَهُ وَبِذَلِكَ أُمِرْتُ
وَأَنَا أَوَّلُ الْمُسْلِمِينَ ﴿١٦٣﴾ ﴾

(سورة الأنعام: الآية ١٦٢:١٦٣)

صدق الله العظيم

Multimedia Information Systems and Digital Library
[IS 460]

Course Description:

Recent advances in digital media technology and rapid growth of social media platforms where multimedia objects such as images, videos and music (audio), and mobile and geospatial data, are increasingly embedded in online social communities. As a result, multimedia has gained enormous potential in improving the traditional educational, professional, business, communication and entertainment processes. To be able to use this potential for transferring these processes into user-friendly multimedia applications, technology is required that can help us access, deliver, browse, search, retrieve, enrich and share multimedia content.

In particular, this course covers such topics as designing multimedia information system, organizing multimedia content, physical storage and retrieval of multimedia data, Content-based Search and retrieval, creating and delivering networked and multimedia presentations, securing multimedia content, digital library and current research directions in this area.

The main objective of the course is to introduce students different types of multimedia data, different techniques to represent, store, manipulate, and retrieve multimedia data residing across global computer networks.

The multimedia information system has been proposed as a result of there being so many kinds of media data needed to be managed currently and traditional information systems mainly based on the relational database technology having no or limited capacity of handling the complex media data including image, video, audio and animation etc. it is characterized by its applying the multimedia database system in which all types of data can be stored, organized, managed and retrieved reasonably and efficiently.

At present, there are three fundamental approaches to implement a multimedia database within the multimedia information system, they are:

(1) Expanding relational database methods;
(2) Object-oriented method;
(3) Hypertext or hypermedia method.

The multimedia information system represents a specific form of information system. This research area suffered many changes in direction due to technology shifts. The general problem is that few years back, multimedia technologies had been limited to relatively simple, stand-alone applications, but multimedia systems, particularly Web-based systems grew in complexity and intervened with many critical issues and challenges for development.

Course Objectives

- Students will be familiar with the main concepts, issues and challenges of ***multimedia information systems*** to better understand, implement, and manage.
- Students will learn methods of design, management, creation, and evaluation of ***multimedia information systems***.
- Theory and practice of digital media production, reception, organization, retrieval and reuse.
- Students will be able to describe and review applicable digital technology with various multimedia categories.
- Students will learn and understand **Digital Library**; concepts, applications, advantages and disadvantages.
- Course will involve group projects in the design and development of information systems with various digital media applications within the recent correlated software packages through *labs*.

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Chapter One

Multimedia Information System

CHAPTER ONE

Multimedia Information System

***Necessity, who is the mother of invention.* –** Plato

"*We are living in the information age*" is a popular saying; therefore, an incredible amount of digital data goes round in the world. Brought to you by television or the Internet, as communication between businesses, or acquired through various sensors like your digital (video) camera. Increasingly, the digital data stream is composed of multimedia data items, i.e. a combination of pictorial, auditory and textual data. With the increasing capabilities of computers, processing the multimedia data stream for further exploitation will be common practice. Processors are still expected to double their speed every 18 months for the near foreseeable future; memory systems sizes will double every 12 months and grow to Terabytes of storage; network bandwidth will significantly improve every 9 months, increasing their resources even faster. So there is enough capacity to fill with multimedia data streams.

Observing how Internet is evolving, it is obvious that users prefer a multimedia style of information exchange and interaction, *including* pictures, video, sound and animation. We foresee that the same turnover will occur in professional life through the various applications. The emphasis in information handling will gradually shift from categorical and numerical information to information in multimedia form: pictorial, auditory and free text data.

The first chapter of this book provides the background, basic concepts, and terminology associated to the trend of the multimedia information system, as the initial step for building and implementing an ideal application of the multimedia information system.

1.1 An information System

Generally, a system can be defined as a group of interrelated components (Sub-systems) working together under control and management toward achieving a common objective by accepting inputs and producing outputs in an organized transformation process through the interaction with specific environment. Figure1.1 below provides the general structure of the general definition for the system concept.

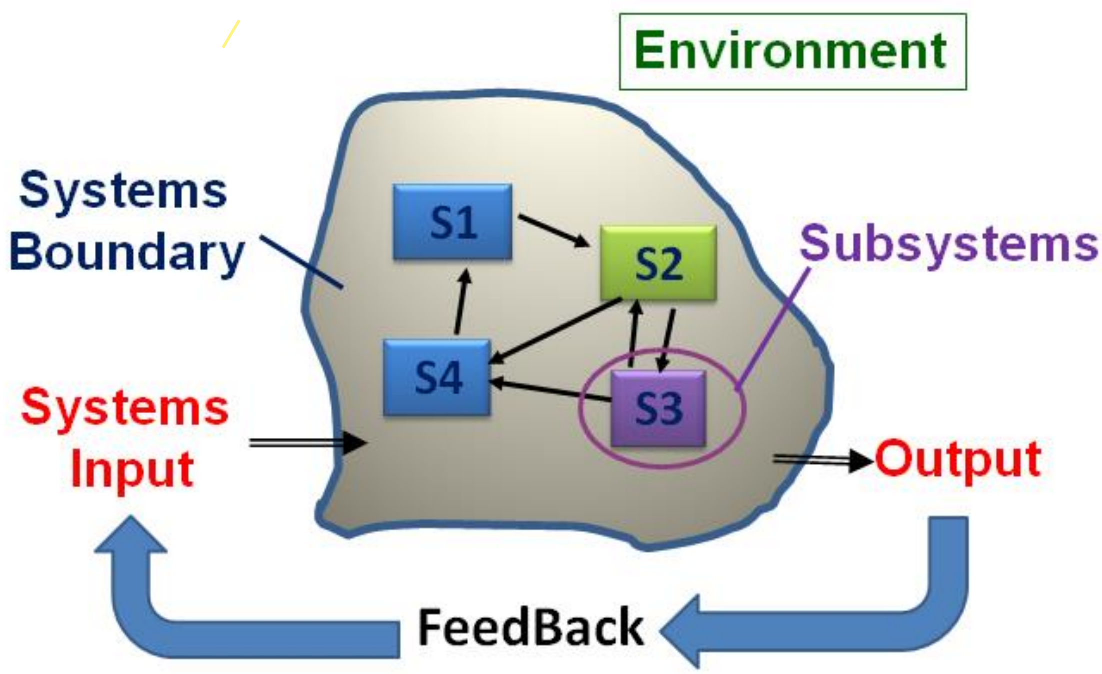


Figure1.1: The General Structure of System Concept.

In particular, **An information System** (IS) can be described briefly as a set of interrelated elements or integrated components that collect (input), manipulate (process), store, and disseminate (output) data and information in addition to provide a corrective reaction (feedback mechanism) in order to meet a predefined objective. An information system can be manual or computerized system. It focuses on the internal rather than the external. Figure 1.2 describes the main components of an information system. The computerized information system is called Computer-Based Information System (CBIS) that mainly means the full automation process of the most manual business processes in an organization.

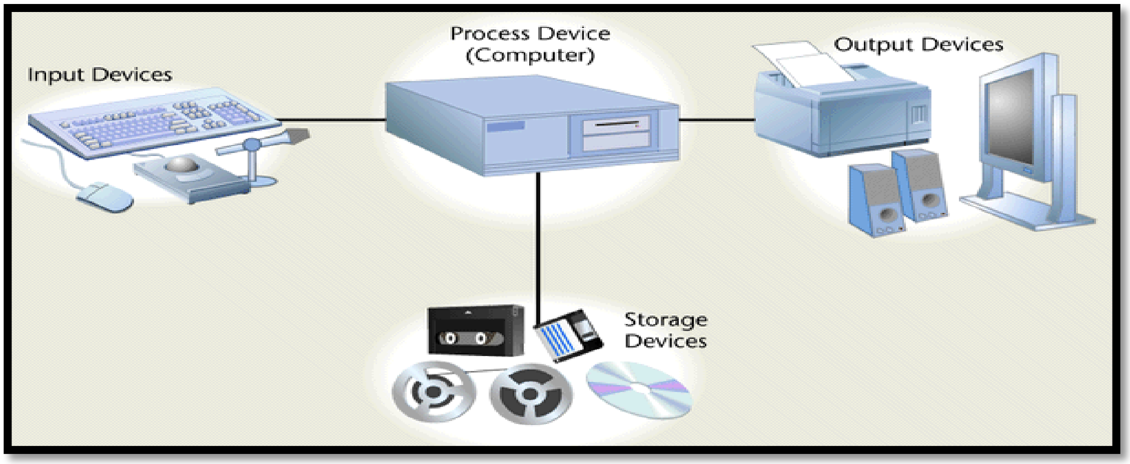


Figure 1.2: An Information System Components

Computer-Based Information System (CBIS); A single set of hardware, software, databases, telecommunications, people, and procedures that are configured to collect, manipulate, store, and process data into information.

Technology Infrastructure; All the hardware, software, databases, telecommunications, people, and procedures that are configured to collect, manipulate, store, and process data into information. This technology infrastructure as shown in figure 1.3 can be briefly described as the following:

- **Hardware;** The physical components of a computer that perform the input, processing, storage, and output activities of the computer.
- **Software;** The computer programs that govern the operation of the computer.
- **Database;** An organized collection of facts and information.
- **Telecommunications;** The electronic transmission of signals for communications; enables organizations to carry out their processes and tasks through effective computer networks.
- **Networks;** Computers and Equipments that are connected in a building, around the country, or around the world to enable and support electronic communication.
- **Internet;** The world's largest computer network, consisting of thousands of interconnected networks,
- **Procedures;** The strategies, policies, methods, and rules for using a CBIS.
- **People** are the most important element in most CBISs. They make the difference between success and failure for most organizations. Information systems personnel include all the people who use, manage, run, program, and maintain the system.

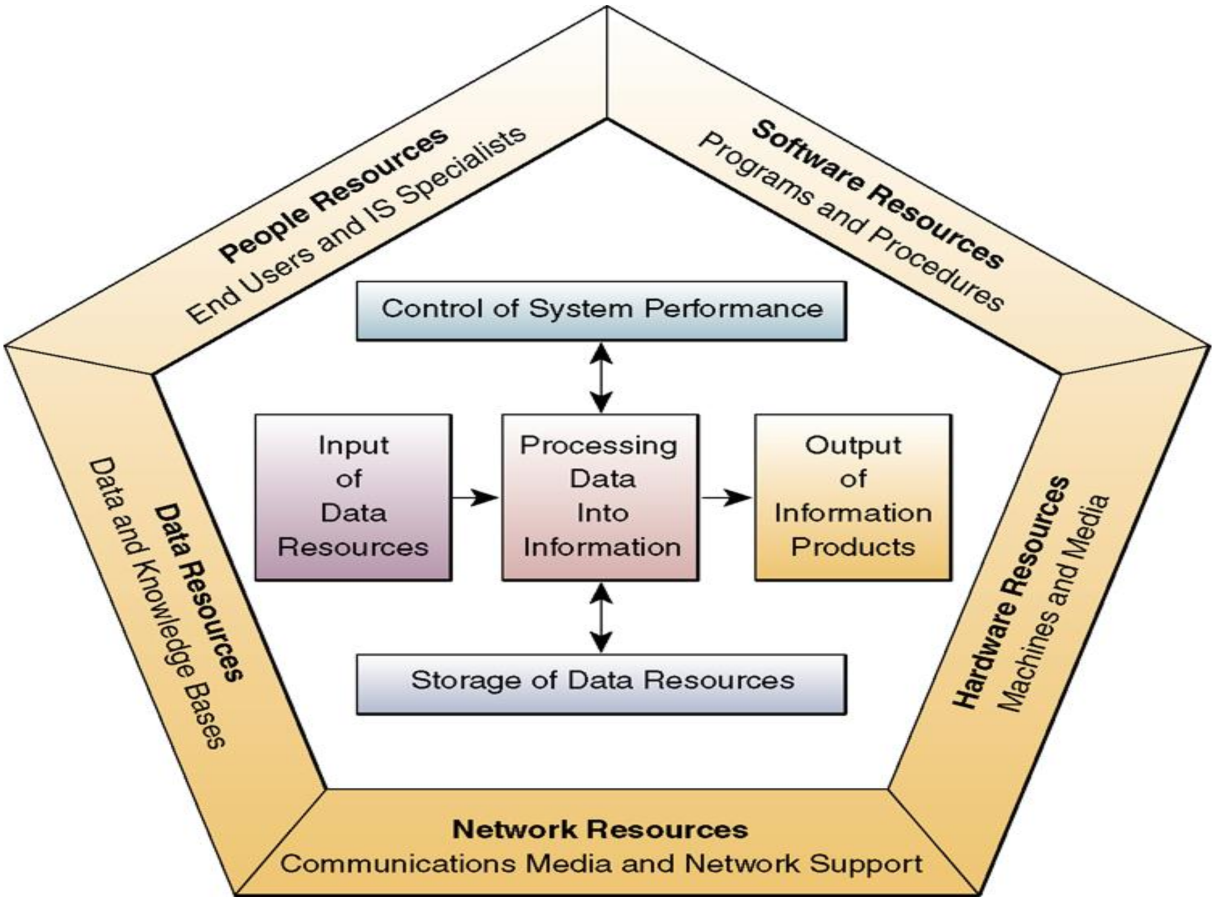


Figure 1.3: The CBIS Technology Infrastructure

1.2 Multimedia

Recently information systems are getting more and more multimedia-based as well as network-based. Clear examples of this trend are various Internet applications for areas *such as*: business, education and entertainment. This evolution together with the generally increasing change rate in organizations and society pose new demands on methodologies and competencies required for developing future multimedia information systems for the Internet. There are various definitions of multimedia, but in a simplified description it can be defined as follows:

> "**Multimedia** is an interactive computer-mediated presentation that includes at least two of the following elements: text, sound, video still graphics images, motion graphics, statistics and animation".

Multimedia is content that uses a combination of different content forms *such as*; text, audio, images, animations, video and interactive content. Multimedia contrasts with media that use only fundamental computer displays *such as* text-only or traditional forms of printed or hand-produced material. Multimedia can be recorded and played, displayed, interacted with or accessed by information content processing devices, *such as* computerized and electronic devices, but can also be part of a live performance. Multimedia devices are electronic media devices used to store and experience multimedia content, as described in figure 1.4. Multimedia is distinguished from mixed media in fine art; *for example*, by including audio it has a broader scope. In the early years of multimedia the term "rich media" was synonymous with interactive multimedia, and "hypermedia" was an application of multimedia.

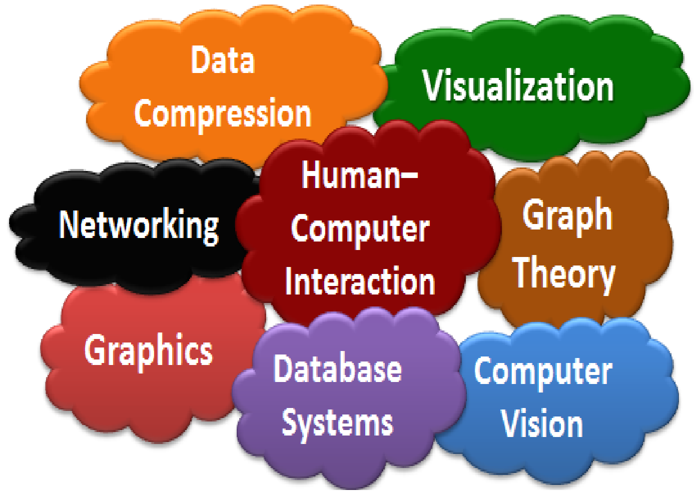
Figure 1.4: Different Content Forms of Multimedia.

When different people mention the term **multimedia**, they often have quite different, or even opposing, viewpoints.

- **A PC vendor**: a PC that has sound capability, a DVD-ROM drive, and perhaps the superiority of multimedia-enabled microprocessors that understand additional multimedia instructions.
- **A consumer entertainment vendor**: interactive cable TV with hundreds of digital channels available, or a cable TV-like service delivered over a high-speed Internet connection.
- **A Computer Science (CS) student**: applications that use multiple modalities, *including* text, images, drawings (graphics), animation, video, sound including speech, and **interactivity**.

From the perspective of multimedia and computer science, there are many interdisciplinary technologies, *such as*;

- Graphics,
- Human–Computer Interaction (HCI),
- Visualization,
- Computer Vision,
- Data Compression,
- Graph Theory,
- Networking,
- Database Systems.



Hypermedia and Multimedia

- A **Hypertext System**: meant to be read nonlinearly, by following links that point to other parts of the document, or to other documents.
- **HyperMedia**: not constrained to be text-based, can include other media, e.g., graphics, images, and especially the continuous media | sound and video. The World Wide Web (WWW) is the best example of a hypermedia application.
- **Multimedia** means that computer information can be represented through audio, graphics, images, video, and animation in addition to traditional media.

Multimedia Presentations may be viewed by person on stage, projected, transmitted, or played locally with a media player. A broadcast may be a live or recorded multimedia presentation. Broadcasts and recordings can be either analog or digital electronic media technology. Digital online multimedia may be downloaded or streamed. Streaming multimedia may be live or on-demand.

Multimedia Games and Simulations may be used in a physical environment with special effects, with multiple users in an online network, or locally with an offline computer, game system, or simulator.

The various formats of technological or digital multimedia may be intended to enhance the users' experience, *for example* to make it easier and faster to convey information, or in entertainment or art, to transcend everyday experience.

1.3 The Multimedia Categories

Multimedia may be broadly divided into **linear** and **non-linear** categories:

- **Linear** active content progresses often without any navigational control for the viewer *such as* a cinema presentation;
- **Non-linear** uses interactivity to control progress as with a video game or self-paced computer-based training. Hypermedia is an example of non-linear content.

Multimedia presentations can be **recorded** or **live**:

- **A recorded multimedia presentation** may allow interactivity via a navigation system;
- **A live multimedia presentation** may allow interactivity via an interaction with the presenter or performer.

Multimedia information - when offered as an option with equal accessibility as the current information forms - will be the preferred format as it is much closer to human forms of communication. Multimedia information presentation from the system to user and interpretation from the user to the system employs our coordinated communication skills, enabling us to control system interactions in a more transparent experience than ever before. More natural interaction with information and communication services for a wide range of users will generate a significant societal and economic value.

Multimedia applications can include various types of media. The main characteristic of a multimedia system is the use of more than one kind of media in order to deliver both content and functionality. Web and desktop computing programs can both involve multimedia components. As well as different media items, a multimedia application will normally involve programming code and enhanced user interaction.

Multimedia items generally fall into one of six main categories [sound, video, animation, text, images and statistics] and use varied techniques for digital formatting. A brief description of the six main categories of the multimedia is illustrated in the following:

Text

It may be an easy content type to forget when considering multimedia systems, but text content is by far the most common media type in computing applications. Most multimedia systems use a combination of text and other media to deliver functionality. Text in multimedia systems can express specific information, or it can act as reinforcement (e.g. support or description) for information contained in other media items. This is a common practice in applications with accessibility requirements. For example, when Web pages include image elements, they can also include a short amount of text for the user's browser to include as an alternative, in case the digital image item is not available.

Images

Digital image files appear in many multimedia applications. Digital photographs can display application content or can alternatively form part of a user interface. Interactive elements, such as buttons, often use custom images created by the designers and developers involved in an application. Digital image files use a variety of formats and file extensions. Among the most common are JPEGs and PNGs. Both of these often appear on websites, as the formats allow developers to minimize on file size while maximizing on picture quality. Graphic design software programs such as Photoshop and Paint.NET allow developers to create complex visual effects with digital images. Images used in multimedia applications can be classified into:

- **Raster**: Derived from photographs, painting programs, and video-discs.
- **Vector**: Line drawings derived from engineering drawings, CAD systems, and vector graphics.
- **Moving**: A sequence of the above with extra clues as to three-dimensional relationships, history, and narrative. Examples are animation or (digitized) video.

Audio/Sound

Notably the human voice – narrations, comments, lectures – but also music, sounds from nature. Audio files and streams play a major role in some multimedia systems. Audio files appear as part of application content and also to aid interaction. When they appear within Web applications and sites, audio files sometimes need to be deployed using plug-in media players.

Popular audio formats include; MP3, WMA, Wave, MIDI and RealAudio. When developers include audio within a website, they will generally use a compressed format to minimize on download times. Web services can also stream audio, so that users can begin playback before the entire file is downloaded.

Video

Digital video appears in many multimedia applications, particularly on the Web. As with audio, websites can stream digital video to increase the speed and availability of playback. Common digital video formats include Flash, MPEG, AVI, WMV and QuickTime. Most digital video requires use of browser plug-ins to play within Web pages, but in many cases the user's browser will already have the required resources installed.

Animation

Animated components are common within both Web and desktop multimedia applications. Animations can also include interactive effects, allowing users to engage with the animation action using their mouse and keyboard. The most common tool for creating animations on the Web is Adobe Flash, which also facilitates desktop applications. Using Flash, developers can author FLV files, exporting them as SWF movies for deployment to users. Flash also uses ActionScript code to achieve animated and interactive effects.

Statistics

Statistical, economic, and mathematical data resulted from various applications that requires graphical (pie-charts or bar-charts) or tabular (spread-sheet) representation.

1.4 Multimedia Information System

Multimedia Information System (MMIS) is differing from this traditional concept of information system according to the types of the data/information representation in the database component, such that **Multimedia** refers to the precise combination of multiple types and formats of media stored and processed in the information system as illustrated in the previous section.

Therefore, **MMIS** can be defined as an information system within multimedia database**. MMIS** is a repository for all types of information object, in computing context; this means all types of digitally representable data. Such systems are complex and multidisciplinary in nature.

The term *Hypermedia* today more and more stands for a trend towards *Integration.* Hypermedia comprises within the approach of a unified, integrated system the different aspects of hardware support, user interfaces, multimedia data, data manipulation and data organization. A superficial analysis of these aspects yields three significant dimensions for the description of a system – *data types*, *application tools* and *system services* & *resources.* 'Full' Hypermedia is in essence identical to the complete volume defined by these dimensions.

However, every currently available hypertext-and hypermedia-system covers only a certain sub-volume of this space. The four main issues of design and implementation of MMIS and their related technologies can be briefly abstracted as shown in Figure 1.5:

1. Semantic Content Extraction
2. Modeling and Storing
3. Multimodal Processing
4. Efficient and Powerful Querying

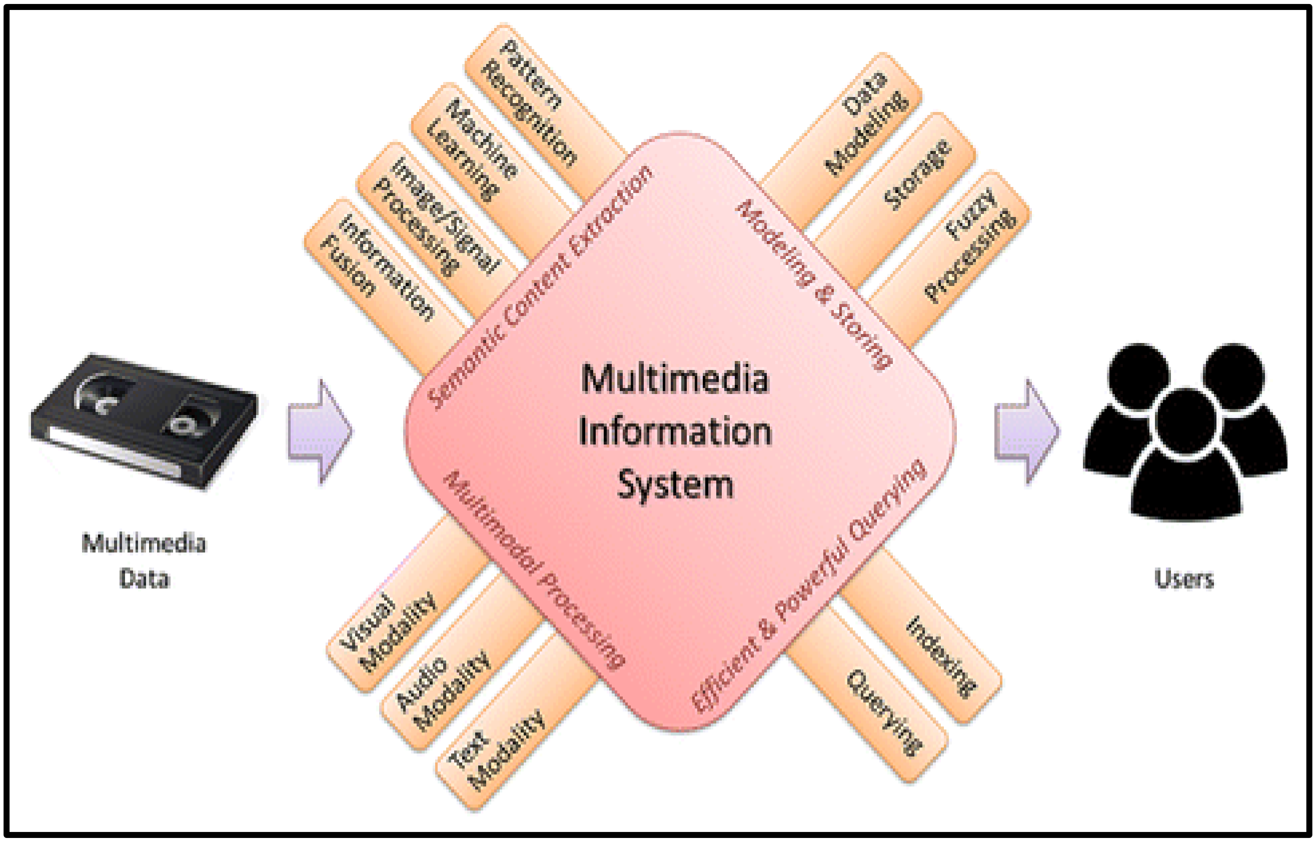


Figure 1.5: The Multimedia Information System

1.5 The MMIS Features

According to the various categories of multimedia data in MMIS; the ideal MMIS should provide these recommended facilities that represented in the following general list of features:

1. MMIS should be able to store everything that can be represented digitally – principally those media listed in the multimedia categories section (Section 1.3).
2. Once everything has been stored, the user must be able to retrieve it. Retrieval falls into three categories:
   - **Presentation.** ***Retrieval by presentation*** relates to data type and data structure, without any sophisticated analysis. It is commonly applied to composite media, i.e. those containing other media. Examples of presentation queries are "Find all documents that have voice comments in them" or "Find all images".
   - **Content**. ***Retrieval by content*** is the process of retrieving documents according to their semantic content. The simplest form of content retrieval is based on manually generated labels - i.e. descriptions entered from the keyboard by an operator. The

other extreme is automatic semantic analysis – i.e. descriptions inferred by the system. In general, labelling makes things easy for the implementor, whereas automatic semantic analysis benefits the user.

- **Association**. ***Retrieval by association*** is the process of retrieving items by associated links to other items. It can be used as a browsing mechanism and subsumes hypermedia.

3. There are a number of ways in which querying may be achieved from the user's point of view:

- **By Data Model.** The user is familiar with the data model and can formulate queries *such as* "What text attributes are stored?" or when classification is provided: "What characterizes this class?"
- **Directly** The user knows exactly what the system stores in relation to each item, e.g. the labels it uses, the primitives it extracts during semantic analysis, or the way it structures composite media. Direct queries are then expressed as logical expressions or set operators, as in conventional databases.
- **By Similarity.** Queries of the form "Retrieve images that are similar to this one" are desirable, but in general they are too vague to be soluble. However, examples do exist: for images, statistical *similarity measures* can be used; for text, an approximate measure of word content can be found using a hashing function to produce *signature files*.
- **By Prototype.** This technique is related to similarity retrieval. Queries take the form of a prototype presented to the database, where the prototype may be either of the following:
    - **Sketches.** A 'shorthand' version of an item is given on-line by the user and the system must try to stretch and compress this sketch to fit stored items. The form that a sketch takes varies from one medium to another, and may be meaningless in some. **An image sketch** might comprise a rough outline of a particular style of house with salient features included *such as* rectangular Georgian windows with multiple panes. **A voice sketch** may be a sentence spoken by the user in a particular accent, dialogue or language. Some of these techniques won't appear for a long time, but they are still valid from the user's viewpoint. An image example that already exists is the Ledeen on-line symbol recognizer**.**

4. In a large multimedia system it is undesirable to present users with a large set of items as the result of a query; what is needed is a measure of the degree to which each item satisfies the query so that they can be ranked and the best matches examined first. For *Prototype Retrieval*, a ranking score can be obtained by measuring the distance of the retrieved item from the prototype. Another source of scores is to assign an importance to each clause of the query; items that satisfy the most important clauses receive the highest score and so on. Scores can be discrete (very good, good, reasonable ...) or continuous (normalized to the range [0, 1] for item).

5. Another retrieval technique that should be provided is ***Browsing***, possibly using hypermedia as a mechanism. The user has a set of items (the entire contents of the system or a subset obtained by query) and is allowed to roam over them. The user may wish to generate his own commented connections between items in a hypermedia fashion. The system should manage the connections for him as sets of 'webs'. Queries can then take the form "Get me web X".

6. In order to fit more items on the screen and to avoid getting the full versions from the system, retrieved items may be displayed as:
   - **Icons** Small pictorial representations relating to the type of the original, but not the content.
   - **Miniatures** The original item reduced greatly in size.
   - **Descriptions** One-line comments about the item's content - for example, operator generated 'headers' or system generated type names.

7. Retrieval should be mixed-media, using the same language to express all forms of media, but possibly with sub-clauses specific to each medium to cope with their different semantics.

8. The system should have a reasonable response time in order to be interactive. Semantic analysis can sometimes take hours or days. Content retrieval can be based on analysis done pre-query - i.e. before the item is involved in a query - or post-query. Pre-query analysis increases storage requirements and post-query analysis increases response time. Lazy evaluation can be used as a compromise, so that analysis is performed on demand and the results retained in the database.

9. Editors should be provided so that users can modify or create new items. Although editors are medium specific, they should all have the same look and feel- e.g. all windows based, with a similar menu hierarchy and similar high-level options. Editors for composite media (webs, documents) could call on the appropriate editors for the media they contain. Many media require modern workstations for display but in a multi-user, distributed system they will vary in resolution, number of bits per pixel and so on. Therefore a workstation will have to assess the incoming items and do one of:

   - Reject them as un-displayable.
   - Alter the items to fit its own screen by transforming resolution, converting colour to grey-level, reducing the number of bits per pixel and so on.
   - Display what it can and replace the rest with icons; this would allow a text-only screen to replace images in a page with a box containing the word IMAGE or a description, while retaining the text.

10. Storage requirements will be huge, running to hundreds of kilobytes for a single high-resolution colour image for example. Therefore, MMIS designers will have to consider each of the following:

- **High Volume Storage Technology** Such as a 'juke-box' of read/write optical disks, or write-once optical tape.
- **Multi-user Access** Since it will be expensive and sought-after, mass storage should be shared between users and ideally between machines.
- **Distributed Architecture** More than one machine should be able to provide database resources. Ideally the location of a particular piece of data should not be apparent to the user, allowing controlled replication of data to speed access.
- **Storage by Reference** An item appearing in more than one composite item is stored only once while the composite items each get a copy of a pointer to it.
- **High Bandwidth Networks** Local-area and wide-area networks to allow multiuser access and distributed architectures.
- **Version Control** A user may wish to modify an existing item and record the item from which it is derived. For storage efficiency, a new version could be stored as a description of the changes made to the parent.
- **Archiving** Some technologies for mass storage are write-once. Therefore, items can remain in an editable state on magnetic disk until completed. Once complete they can be stored permanently or *archived.* If it is ever necessary to change an archived item, it must be retrieved into an editable state and re-archived. This is another reason to provide version control.
- **Data Compression** Data compression reduces storage requirements and speeds transmission through networks.

1.6 The MMISs Applications

Computer-Based Multimedia Information Systems (MMISs) have been a popular topic in recent years for two main reasons:

- **First**, the various technologies required to design and implement MMISs are only now becoming widely available. The main technological requirements advanced storage media for mass storage, high bandwidth networks for fast access and sophisticated workstations for meaningful presentation.
- **Secondly**, several applications are multimedia in nature or would be enhanced by multimedia techniques.

Also, Multimedia finds its application in various areas including, but not limited to; advertisements, art, education, entertainment, engineering, medicine, mathematics, business, scientific research and spatial temporal applications.

The development of multimedia applications is an expensive process with regard to manpower, hardware, software, and multimedia resources that are spent on it. This fact asks for means that can help to protect and spread those investments, mainly the different types of multimedia and related description data. In computer science database systems are approved facilities to make data and conceptual knowledge, stored in a central pool, accessible to different users and applications. In the case of multimedia applications, there are many new implications, originating from the characteristic properties of multimedia, which must be considered in order to apply the traditional techniques of database systems to the much more complex domain of multimedia database systems (as will be describes in chapter 3). Some of the MMISs applications can be one of the following:

Education/Training

Advances in multimedia computing technologies offer new approaches to support computer assisted education and training within many application domains. Novel interactive presentation tools can be built to enhance traditional teaching methods with more active learning.

In education, multimedia is used to produce computer-based training courses (popularly called CBTs) and reference books like encyclopedia and almanacs. A CBT lets the user go through a series of presentations, text about a particular topic, and associated illustrations in various information formats. Edutainment is the combination of education with entertainment, especially multimedia entertainment. Learning theory in the past decade has expanded dramatically because of the introduction of multimedia. Several lines of research have evolved, e.g. cognitive load and multimedia learning.

From multimedia learning (MML) theory, David Roberts has developed a large group lecture practice using PowerPoint and based on the use of full-slide images in conjunction with a reduction of visible text (all text can be placed in the notes view' section of PowerPoint). The method has been applied and evaluated in 9 disciplines. In each experiment, students' engagement and active learning has been approximately 66% greater, than with the same material being delivered using bullet points, text and speech, corroborating a range of theories presented by multimedia learning scholars like Sweller and Mayer. The idea of media convergence is also becoming a major factor in education, particularly higher education. Defined as separate technologies *such as* voice (and telephony features), data (and productivity applications) and video that now share resources and interact with each other, media convergence is rapidly changing the curriculum in universities all over the world.

Offices

Information may arrive in an office in many different forms, each being processed and field in a different manner. *For example*, documents, memos, telephone messages, faxes, etc. Since the output of offices is moving towards "electronic publishing", why not collect and process the information in the same way?

Medicine/Medical Records

A patient's medical record may consist of case histories, X-rays, notes or sketches from consultations, test results, etc. In addition, several new imaging techniques generate digital or video data directly- computer tomography, magnetic resonance and ultrasound. In medicine, doctors can get trained by looking at a virtual surgery or they can simulate how the human body is affected by diseases spread by viruses and bacteria and then develop techniques to prevent it. Multimedia applications *such as* virtual surgeries also help doctors to get practical training.

Libraries/Museums/Galleries

A Digital library may contain many gigabytes or even terabytes of different type of data *such as* text, images, video and audio files. Therefore, it requires large storage capacity. Hundreds and thousands viewers can access and search a digital library at the same time. Therefore, it requires high data bandwidth in and out from the storage subsystem of a digital library. The service of a digital library should be available at all time. Therefore, certain type of fault tolerance capability should also be supported in a digital library.

Digital libraries require not only high storage space capacity but also high performance storage systems which provide the fast accesses to the data. These contain vast amounts of data ranging from literary works to archaeological artifacts, all currently accessed by manually generated indexes (Digital libraries will be described in details in chapter five of this book).

Museums

- Mixed media search tools: keyword and visual
- Virtual tour (using panoramic and 3D view)
- Zoom view gallery: multi-resolution
- Watermark protection (invisible)
- Balanced use of aesthetic, informational, and technical components
- Main Issues:
  - Acquisition, representation, user interfaces, search tools, copyright protection.

Computer Aided Design (CAD)

Engineering and various design applications, *for example*; blueprints, simulation, or interactive design with 3D rotation and scaling of objects.

Geographic Information Systems/ Travel/Tourism

Database within the geographic applications can contain different types of maps, satellite images, demographics, even tourist information. The use of multimedia technologies capabilities within GIS, can contribute to the development of decision support systems closer to the reality. The present work aims to create new functions for a multimedia GIS to give to the GIS user the possibility to perform dynamic spatial simulations and a more realistic view of the objects and spatial phenomena.

Geographic Information System, in which a lot of information is disciplined, is a technique that makes life easier. It is called Multimedia Geographic Information System (MMGIS) due to the association with geographic information of multimedia data *such as* text, audio, different types of photos and video. Figure 1.6 describes the integration of the GIS and multimedia technologies. The system which appeals both to the eye and to the ear yields cultural, scientific and popular benefits on the subject. In the era of mobile communications, multimedia information system, provided from the internet, will attract more attention from tourists, and it will be used easily. The tourism sector which has important cultural, economic and social aspects should be addressed at large.

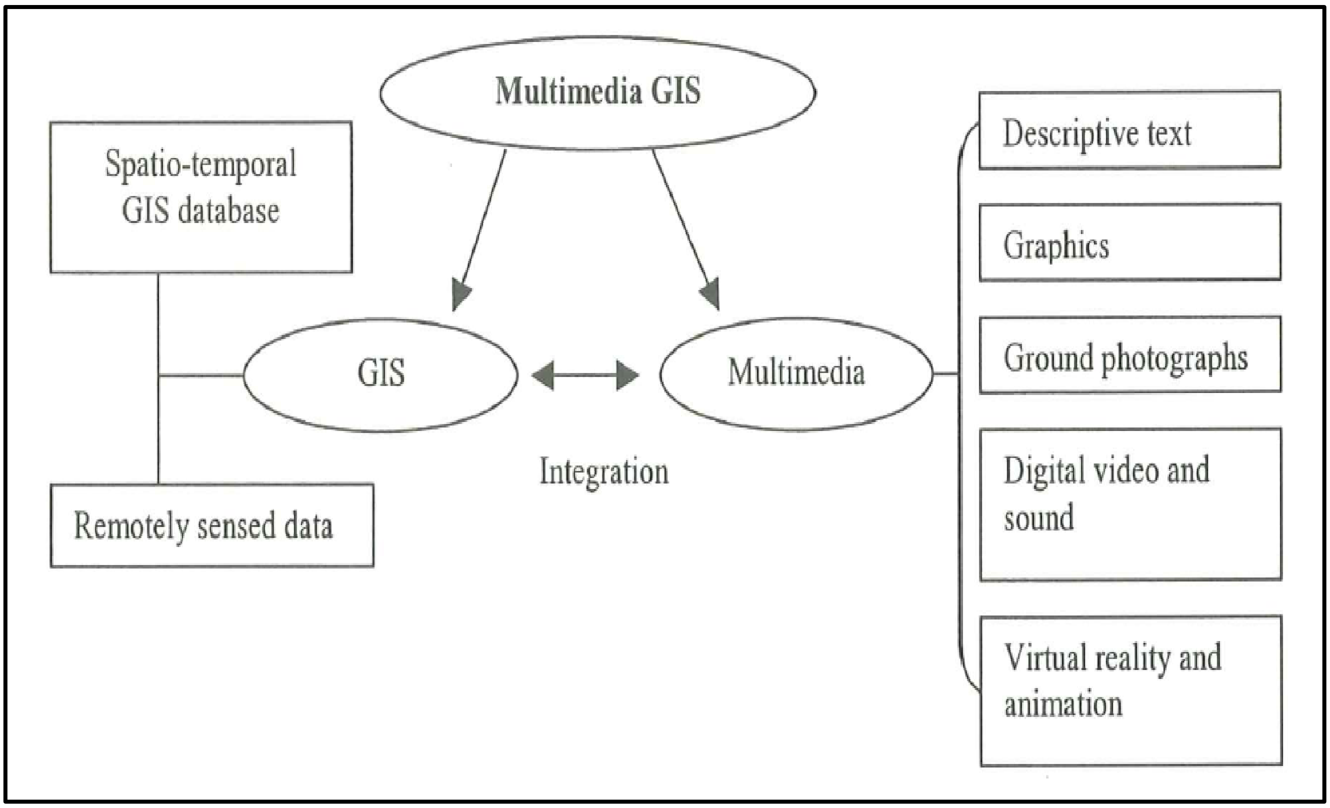


Figure 1.6: Multimedia Geographic Information System

Journalism

Newspaper companies all over are trying to embrace the new phenomenon by implementing its practices in their work. While some have been slow to come around, other major newspapers *like* The New York Times, USA Today and The Washington Post are setting the precedent for the positioning of the newspaper industry in a globalized world.

News reporting is not limited to traditional media outlets. Freelance journalists can make use of different new media to produce multimedia pieces for their news stories. It engages global audiences and tells stories with technology, which develops new communication techniques for both media producers and consumers. The Common Language Project, later renamed to The Seattle Globalist, is an example of this type of multimedia journalism production.

Multimedia reporters who are mobile (usually driving around a community with cameras, audio and video recorders, and laptop computers) are often referred to as mojos, from mobile journalist.

Engineering

Software engineers may use multimedia in computer simulations for anything from entertainment to training such as military or industrial training. Multimedia for software interfaces are often done as a collaboration between creative professionals and software engineers.

Mathematical and Scientific Research

In mathematical and scientific research, multimedia is mainly used for various purposes, *such as*; modeling, virtual reality and simulation. *For example*, a scientist can look at a molecular model of a particular substance and manipulate it to arrive at a new substance. Representative research can be found in journals such as the Journal of Multimedia.

Creative Industries

Creative industries use multimedia for a variety of purposes ranging from fine arts, to entertainment, to commercial art, to journalism, to media and software services provided for any of the industries listed below. An individual multimedia designer may cover the spectrum throughout their career. Request for their skills are range from technical, to analytical, to creative.

Commercial Uses/Promotional/Retail/Point-of-Sale/Shopping

Much of the electronic old and new media used by commercial artists and graphic designers is multimedia. Exciting presentations are used to grab and keep attention in advertising. Business to business and interoffice communications are often developed by creative services firms for advanced multimedia presentations beyond simple slide shows to sell ideas or liven up training. Commercial multimedia developers may be hired to design for governmental services and nonprofit services applications as well.

Entertainment/Fine Arts/Games

Multimedia is heavily used in the entertainment industry, especially to develop special effects in movies and animations (VFX, 3D animation, etc.). Multimedia games are a popular pastime and are software programs available either as CD-ROMs or online. Some video games also use multimedia features. Multimedia applications that allow users to actively participate instead of just sitting by as passive recipients of information are called interactive multimedia. In the arts there are multimedia artists, whose minds are able to blend techniques using different media that in some way incorporates interaction with the viewer. One of the most relevant could be Peter Greenaway who is melding cinema with opera and all sorts of digital media. Another approach entails the creation of multimedia that can be displayed in a traditional fine arts arena, *such as* an art gallery. Although multimedia display material may be volatile, the survivability of the content is as strong as any traditional media. Digital recording material may be just as durable and infinitely reproducible with perfect copies every time.

Review Questions

Q1. Explain briefly the relation between these concepts: System, Information System, and Multimedia Information System.

Q2. "Necessity, who is the mother of invention" … apply these words to the emergence of the concept of Multimedia Information System.

Q3. Describe in details the technology infrastructure of the CBIS – what is the main addition to the Multimedia Information System.

Q4. When different people mention the term multimedia; they often have quite different, or even opposing, viewpoints… Explain these various viewpoints of multimedia concept.

Q5. From the perspective of multimedia and computer science, there are many interdisciplinary technologies, *such as*; ………, …...…, ………., …..…, ….……, ………., …...… **Complete.**

Q6. Give a description (***with examples***) for the six main multimedia categories.

Q7. State the four main issues of design and implementation of MMIS and their related technologies

Q8. Explain **(*at minimum*)** six main features for the Multimedia Information System.

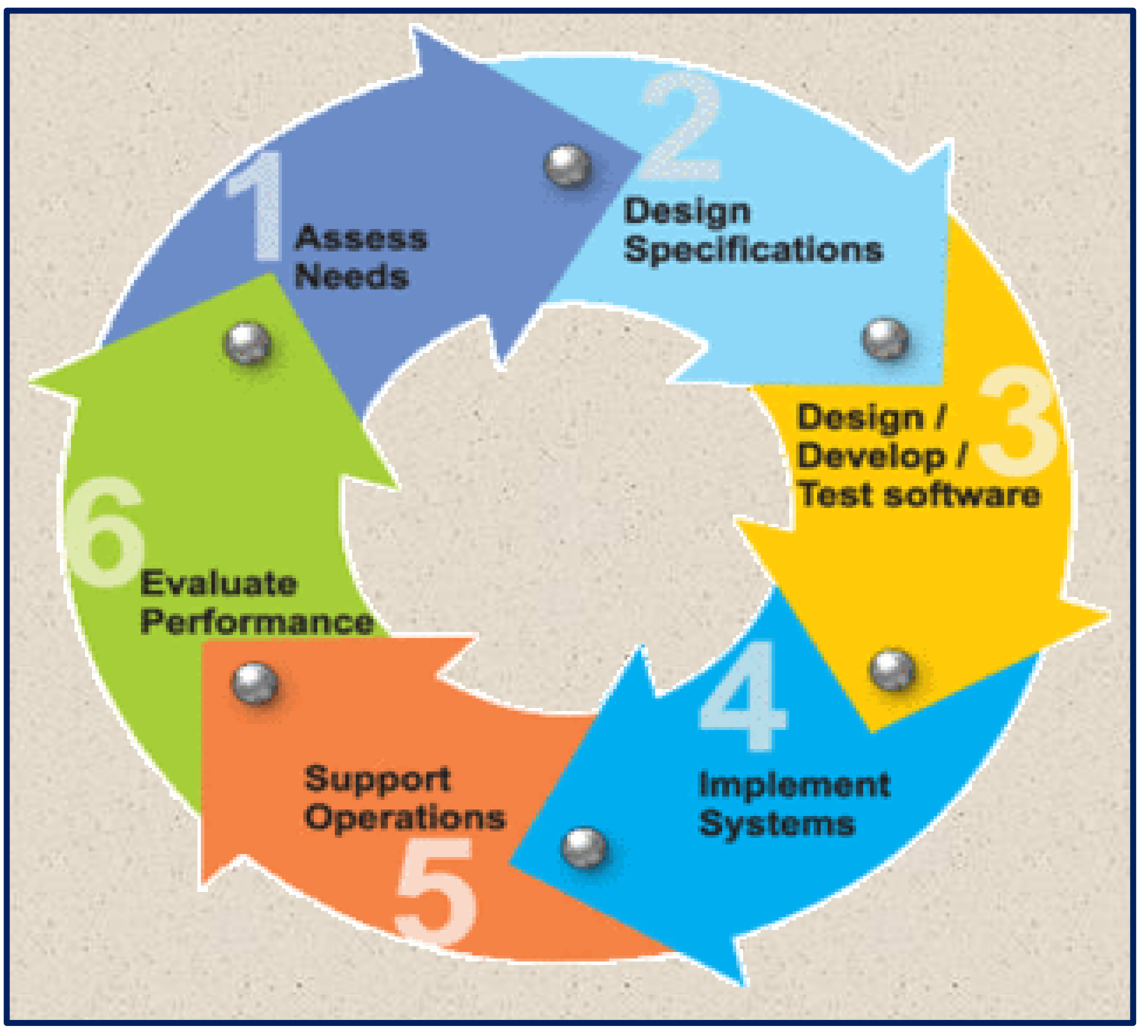
Q9. Computer-Based Multimedia Information Systems have been a popular topic in recent years … Give reasons.

Q10. Multimedia finds its application in various areas … Discuss in detail **(*at minimum*)** six main applications for the Multimedia Information System.

Q11. Describe ***with figure only*** the structure of the Multimedia Geographic Information System.

CHAPTER TWO

The Development of Multimedia Information Systems



<u>Chapter Two</u>

The Development of Multimedia Information Systems

"Give me six hours to chop down a tree and I will spend the first four sharpening the axe". *Abraham Lincoln (1809 - 1865)*

In order to obtain accurate results and better products for the computer science applications, it is necessary to follow the scientific methodologies and systematic procedures which adopted with sequential phases and specific steps.

2.1 Introduction

The use and development of computerized information systems has changed significantly since such systems were first introduced on the market in the 1960s. Information systems have gone from being only regarded as pure business applications to being integrated parts of public products and services. The users of information systems were earlier mainly professionals while modern information systems applications are often aimed for private use as well. An important reason for this is the increasing use of the Internet as a platform for more and more information system applications. In order to make these applications functional and easy to use, interactivity and multimedia based user interfaces are of great interest.

As multimedia information systems begin to infiltrate organizations, there arises a need to capture and disseminate knowledge about how to develop them. Little is thus far known about the realities of multimedia systems development practice, or about how the development of multimedia systems compares to that of 'traditional' information systems. Multimedia information systems development is regarded as comprising the parallel processes of software engineering as well as content development and project management. The process appears to be a multidisciplinary effort requiring cooperation of people from many different backgrounds with their own specific competencies, methodologies and views of the world. A large variety of competencies will be required for developing the future multimedia information systems because of their multidisciplinary nature.

Technically, interactivity and multimedia raise new challenges in several areas. *For instance*, new techniques are needed for representing, storing and manipulating new data types (e.g. still pictures, videos, audio, animation) and not to forget transmission of huge data collections over different networks. Representation of knowledge and experience in information systems is an adequate challenge as well. More expressive media opens up new opportunities to create effective visual applications. Building interesting multimedia applications is also a question of dramaturgy. Well-proven concepts from traditional storytelling, music, literature, drama, arts etc. are important as well, because multimedia presentations are fundamentally not different from any other type of human communication.

The creation of multimedia software is similar to software development *(that described briefly in Figure 2.1)* in general, but particular skills and additional techniques are required for the creation of the content part of the application itself.

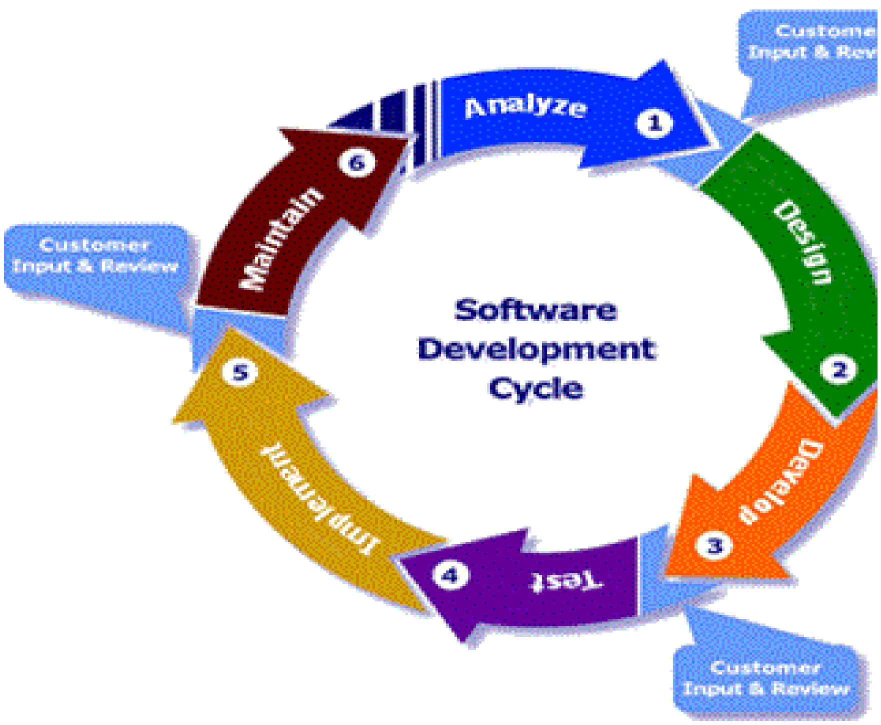


Figure 2.1: Software Development Cycle

"Multimedia" simply means being able to communicate in more than one way. Originally the term multimedia was used by institutions who run distance learning courses in which they deliver content via a combination of text, TV, telephone, audio cassette and the radio. Multimedia -as defined previously in chapter one- is an interactive computer-mediated presentation that includes at least two of the following data types: text, sound still graphics images, motion graphics, statistics and animation".

The term interactive differentiates this definition from several other definitions. The concept of interaction means that the user has the possibility to react to the material presented and the reaction causes a selection among alternative actions by the system. Interaction opens up possibilities to actively involve the user, i.e. by letting him/her affect the communication process. Active involvement normally leads to enjoyment that in turn facilitates learning. Mixing forms of expression is also critical to make an impression on the user. Theatre and movies are other examples of media that mix different forms of expression in order to create an illusion that makes an impact on the audience. Virtual reality attained by multimedia is a parallel to this, providing the user with a controlled environment that gives an illusion of being real. By this, the challenge of multimedia is to develop applications that offer more and more reality-like visions.

2.2 Multimedia vs. Traditional Information Systems Development

An information system is defined as a system that manages information by: collection, processing and manipulation, storage, transmission and display of information.

A multimedia information system is defined as a system that involves; generation, representation, storage, transmission, search and retrieval, delivery, production/authoring tools, compression and formats, file system design, networking issues, database management, server design, and streaming of multimedia information.

Generally, a typical multimedia project is divided into a design phase and a development phase, in all comprising seven main activities as shown in Figure 2.2.

DESIGN			**DEVELOPMENT**			
Brainstorming & Storyboarding	Flowchart & Design	Prototyping & User Testing	Media Production	Programming & Media Production	Programming & Debugging	Programming & Final Debugging

Figure 2.2: The Phases and Steps of Multimedia Production.

As the design phase is finished, approximately 30% of the work should be finished. The development phase contains media production, programming and debugging. The media production is about developing graphics, sounds, animations, text, etc. The programming concerns assembling all media into the structure and functions, defined in the design. There is some iteration in the process (programming and debugging), but the process seems to be waterfall-like and the process is strongly product oriented.

The comparison of information systems development and multimedia development is based on a lifecycle model for information systems as presented in Figure 2.3. Comparing the lifecycles of information systems and multimedia systems has several interesting issues. First of all, the lifecycle for information systems is more directed towards organizational needs, while the multimedia system lifecycle is more products oriented.

Information System Lifecycle

Pre-study & Planning	Analysis	Design	Implementation	Installation & "Distribution"	Operation & maintenance	Termination

Multimedia System Lifecycle

Ideas & Needs	Manuscript	Production	Follow-up	Termination

Figure 2.3: Comparison between the lifecycles of information systems and multimedia systems.

The first step in the two different lifecycles in Figure 2.3 is quite different. The starting point in information systems development is a particular organization and its problems, and various solutions can be discussed. It is not even sure that developing an information system is the solution to the problem at hand. Multimedia systems development on the other hand is a process that from the beginning is directed towards a certain product based on concrete ideas or needs.

The manuscript step corresponds quite well with *analysis* and *design* in the information systems lifecycle, but the focus is different. In information systems development, information and functions are in focus, while interactivity, navigation and possibly some kind of a story are emphasized in multimedia development.

Implementation, installation and *distribution* are mainly concerned with programming and testing in an information systems lifecycle, which can be compared with *production* in a multimedia context.

Multimedia development appeared to be a composition of three main processes, ***software engineering*** and what traditionally is regarded as ***content development***. The third process is the overall management and control of the whole project (***project management and marketing***). The structure of the relation between the three processes is clarified in Figure 2.4. In the content process, the content is created or retrieved from various sources and prepared for realization. The software engineering process is about formalizing and coding the content and making it run as defined in the content process.

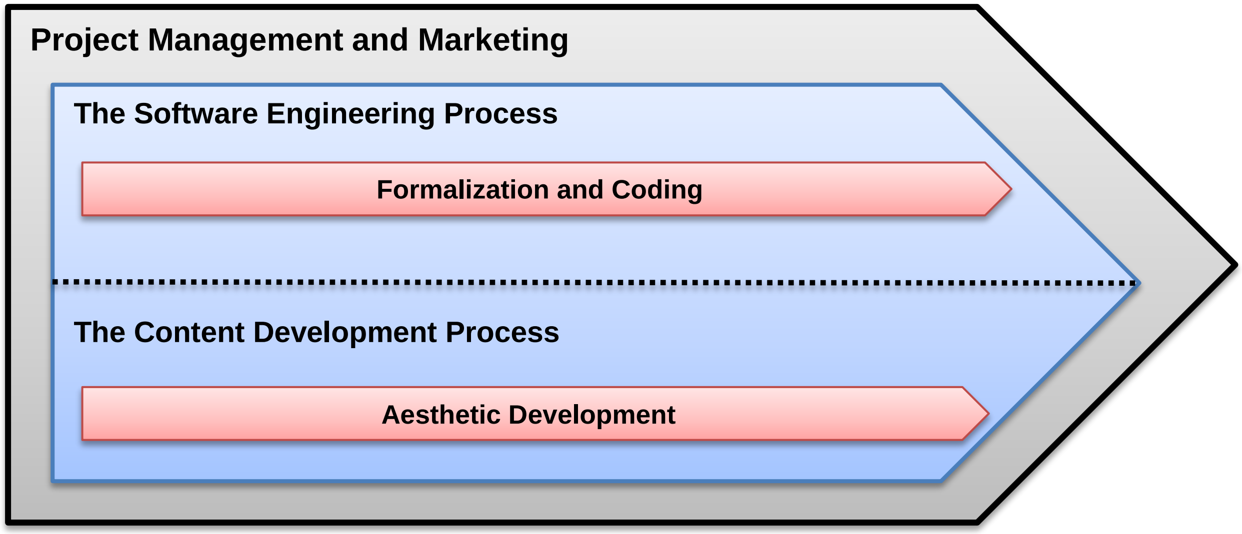


Figure 2.4: Developing multimedia information systems can be regarded as three parallel processes; a Software Engineering process and a Content Development process and an overall Management Process.

Multimedia systems are based on the combination of both computer software and hardware. From that point of view, their development does not differ from any other computerized information system. Common software engineering techniques and development methods can be applied in the software process of a multimedia project. Several methods and techniques are used for managing and controlling software engineering processes, and the competencies needed are well defined, even if they differ slightly from methodology to methodology and from project to project.

When it comes to content development, the competencies needed vary as well. A large part of the content is of an aesthetic nature. The aesthetic content often exists in non-electronic forms, so the main work of the content producers in a multimedia project can be to convert the original content to an electronic form. Each competence of the aesthetic production belongs to a discipline that has its own methods. One major challenge is to coordinate all the involved disciplines and various ways of working into a homogeneous process.

Results of the aesthetic development can be design of graphics, audio, photos, animations, text etc. Stories or scenarios are also a matter of aesthetic development. They and the characters in the stories can define or have great impact on the design of the system. The software engineering and the content development processes can start simultaneously, which is quite common in the computer game business, but normally the content part is planned and partly developed before the software engineering process starts. The two activities run of course in parallel through implementation and testing, as the "content" process is often affected by different technical issues and vice versa.

2.3 Competencies required for Multimedia Development

Multimedia development is clearly a multidisciplinary issue. Several competencies are needed from the fields of engineering, fine arts and media as well as from project management and marketing. Comparisons can be made to both the film industry and the advertisement business. In these businesses, many competencies are coordinated to develop an idea and to present it in a form that affects people in a certain manner.

Coordination of all the needed competencies is of importance in order to keep every project on track as well as within budget and time frames. It is also necessary to facilitate an understanding among the various competencies. An understanding of each other's working conditions makes it easier to avoid sub-optimization within one domain that may cause problems somewhere else in a project.

Here, some competencies possibly desirable in multimedia production are listed. The list is far from complete, but it gives an indication of the complexity and specific nature of the area. In the following list, the competencies are associated to the three parallel processes of multimedia development that previously presented in Figure 2.4.

The Overall Project Management Process

- ***Marketing***
  A key factor for bringing in money to pay the costs of the project and hopefully bringing the investors some return on their investment.

- ***Project management***
  Responsibility for providing a general understanding of the process as a whole, which competencies and tools that are available, how they can be combined as well as where and when they fit in the process. Day-to-day management of people and other resources as well as customer relationships must be taken care of. Every project must be run on time and within budget.

The Software Engineering Process:

- ***Technical Art Direction***
  A person who has a good knowledge and expertise of software engineering as well as animation and graphical design and narration. This person must be able to judge what is technically possible to implement and act as a mediator between the software engineering staff and the content staff.

- ***Software Design***
  This activity can take different directions depending on whether the system is designed and coded from scratch or if it is component-based. The content of the system can also affect the design of the technical system. It can for instance be a question of managing various data-types and supporting certain behavior of objects in the system.

- ***Information Management***
  As information in multimedia systems is collected from various internal and external sources, there is a need for management and integration of information and data.

- ***Computer Programming***: Implementation (coding) and testing of the design.

- ***Network:*** Many multimedia applications are designed for network use, as for example the web.

- ***Interface***: Design of the effective user interface with respect to usability aspects and navigation.

The Content Process

- ***Art Direction and Graphical Design***:
  Creation of the graphical parts of the system. There can be many subcategories, directed towards e.g.; 3D, 2D, still images, animation, stage setting and morphing.

- ***Business Analysis***:
  Identification of the business concepts, precise requirements, and different strategies necessary for progress monitoring and control.

- ***Playwriting***
  Composition of a possible story, and a dialog and adapting it to the possibilities of expression that the media offers.

- ***Layout***: Design, formatting and layout of text and its combination with graphics.

- ***Communication***: Design of interaction, navigation and interface issues.

- ***Photography***: Ordinary photographing and video filming are needed as well as editing.

- ***Audio***: Audio recording as well as editing.

- ***Acting***
  Actors are necessary both for acting in video-sequences, and as models for photographs and for lending their voices to different characters or for storytelling.

- ***Pedagogy***: Pedagogy is essential in the development of all computer-aided learning media.

- ***Behavioral Science***
  Psychologists and anthropologists may be of great value in defining how to adopt a product to different customer categories, legal and ethical groups.

- ***Law***: Lawyers should be involved to deal with both contracts and intellectual property rights.

- ***Domain Expertise***
  Specialists are required from the business of main interest for the actual project as well as technical writers, light operators etc.

2.4 Multimedia Information System Development Life Cycle

Multimedia system development process involves a number of successive phases like traditional software system development and is known as Multimedia System Development Life Cycle (MSDLC) that described in Figure 2.5. The suggested five phases of MSDLC can be defined as follows:

- **System Definition**
- **System Design**
- **Tools Selection**
- **Authoring/Rendering**
- **Testing**

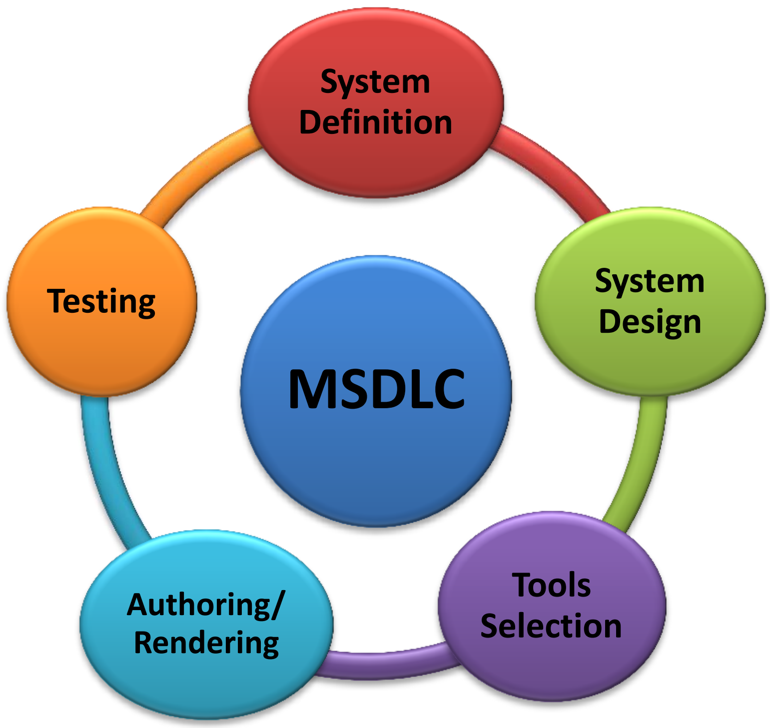


Figure 2.5: The Multimedia System Development Life Cycle (MSDLC)

2.4.1 Phase One: Defining the system to be developed

To develop a worthy multimedia application, presentation or program, it is valuable to understand precisely who the user is and what are his precise requirements, *such that* customer satisfaction and achievement of planned objectives is the main objective of the project.

In order to create a multimedia application; the developer should consider the following critical issues:

- Level of understanding of the audience
- Expectation of the users
- Goal of presentation (training/entertainment)
- Allocated time
- Type of presentation required (text, graphics, sound, video, animation or combination)
- Interactive/non-interactive presentation
- Impact of the presentation to the audience (instant or long-term).

Having all these details firmly in hand will help the multimedia developer to create a successful product with effective components.

Starting from a requirement analysis for an open hypermedia system, we identify the different task scopes of the system. We then map the task scopes onto a conceptual architecture and describe the different architectural and descriptive elements resulting from this mapping. The systems' architectural elements are the components mass storage, object, session and presentation-interaction management. On the descriptive side the Hyper Picture concept provides information objects, extents, functions bindings, events and actions as atomic elements for the definition of the interaction between user, operating system and data objects.

2.4.2 Phase Two: System Design

From the requirements analysis in the earlier phase and with a clear understanding of the key multimedia data structures, algorithms, and protocols, a development team can make smarter and perfect multimedia application. Most common way to start design is by composing an outline of the sequences and locks of information that will appear on the screen. This determines the amount of information-text, graphics, clickable objects which will be presented on each screen.

It is also the time to establish a navigation methodology for the user. The developer has to decide whether there will be a navigation bar with arrows leading from scene to scene, or there will be text or objects that the users should click to jump argon the entire program.

The storyboard can be used for a great deal of animation or many different scenes. Used by film directors for productions ranging from 30-second television commercials to feature-length motion pictures, the storyboard consists of sketches of the scenes and actions.

Mapping out a storyboard helps the author to recognize gaps in logic. Some multimedia authoring programs provide facilities for drawing and organizing the storyboard frames.

2.4.3 Phase Three: Tools Selection

Multimedia applications are a representative example for the integration of modern hardware technology and advanced software techniques. New technical devices support the physical processing, storage, communication, and rendering of various types of media. Most of these hardware components have related counterparts on the side of software, *such as* device drivers or supporting software subsystems. Together they form an appropriate foundation for advanced applications in complex, heterogeneous environments.

Besides these more formally and physically oriented characteristics, sophisticated application types show a strong requirement for conceptual structures and logical relations. Contrary to basic multimedia representation systems, integrated, content-oriented multimedia applications require a much larger effort for the integration of logical and physical objects. This dualism of form and content can be made evident, *for example*, by the comparison of multimedia and hypermedia where multimedia is the formal foundation, conceptually augmented by the logical content of hypertext and hypermedia.

Multimedia product requires many types of software tools, for instance, creating text often requires a work processor; working with digital images requires graphics software; using video requires a video-capture program and editing software; sound often requires its own editing software. All of this software is used to generate the content. When the content is ready, it needs to be assembled in a process called multimedia authoring.

This process requires still another type of software, which can understand different types of media; combine them, control the sequences in which they appear, and create navigational tools for the user interface. The tools used for multimedia depends largely on the variety of media to be included. For a simple text-and-graphics slide show type of presentation, a presentation software program should be enough. The categories of multimedia software tools briefly examined here are:

1. **Music Sequencing and Notation**
2. **Digital Audio**
3. **Graphics and Image Editing**
4. **Video Editing**
5. **Animation**
6. **Multimedia Authoring**

For a concrete appreciation of the current state of multimedia software tools available for carrying out tasks in multimedia, we now include a quick overview of software categories and products as shown in table 2.1. These tools are really only the beginning—a fully functional multimedia project can also call for stand-alone programming as well as just the use of predefined tools to fully exercise the capabilities of machines and the Internet.

Table 2.1: The Categories of Multimedia Software Tools.

Multimedia Categories	Multimedia Software Tools
Music Sequencing and Notation	Cakewalk Pro Audio Finale, Sibelius
Digital Audio	Adobe Audition Sound Forge Pro Tools
Graphics and Image Editing	Adobe Illustrator Adobe Photoshop Adobe Fireworks Adobe Freehand
Video Editing	Adobe Premiere CyberLink Power Director Adobe After Effects Final Cut Pro
Animation	**Multimedia APIs:** Java3D DirectX OpenGL **Animation Software:** Autodesk 3Ds Max Autodesk Softimage Autodesk Maya

GIF Animation Packages

For a much simpler approach to animation that also allows quick development of effective small animations for the Web, many shareware and other programs permit creating animated GIF images. GIFs can contain several images, and looping through them creates a simple animation.

Linux also provides some simple animation tools, such as `animate`.

One could enliven the offering by adding preexisting graphics form the hundreds of commercially available CD-ROM collections of clip art, clip sound, and clip video. These clop collections store small fields in the proper file formats for use in wide range of multimedia applications and programs. A user can use sophisticated sound edition program, to splice together segments or add sound effects electronically, *for example*, echoes to the sounds. Users can do the same kind of electronic editing for video. The most popular program for combining the elements of a multimedia presentation is ***Macromedia Director***. In Director, the multimedia author assembles each element-text, graphics, sound, and video into separate “tracks”.

The program helps the author to synchronize all the various multimedia elements. For instance, a crash sound effect is heard when the two animated object collide. The director generates files that contain the entire multimedia presentation ready for distribution on disk or CD-ROM, or to be played over an integrative television or through the internet.

2.4.4 Phase Four: Authoring/Rendering

After creation of all the multimedia contents, it is required to put them all together. For a complex product created with the use of a sophisticated tool *such as* director, the multimedia authoring generally is performed by a skilled multimedia developer or programmer.

Multimedia Authoring

Tools that provide the capability for creating a complete multimedia presentation, including interactive user control, are called *authoring* programs.

Adobe Flash

Flash allows users to create interactive movies by using the score metaphor—a timeline arranged in parallel event sequences, much like a musical score consisting of musical notes. Elements in the movie are called *symbols* in Flash. Symbols are added to a central repository, called a library, and can be added to the movie’s timeline. Once the symbols are present at a specific time, they appear on the Stage, which represents what the movie looks like at a certain time, and can be manipulated and moved by the tools built into Flash. Finished Flash movies are commonly used to show movies or games on the Web.

Adobe Director

Director uses a movie metaphor to create interactive presentations. This powerful program includes a built-in scripting language, Lingo, which allows creation of complex interactive movies. The “cast” of characters in Director includes bitmapped sprites, scripts, music, sounds, and palettes. Director can read many bitmapped file formats. The program itself allows a good deal of interactivity, and Lingo, with its own debugger, allows more control, including control over external devices.

Dreamweaver

Dreamweaver is a webpage authoring tool that allows users to produce multimedia presentations without learning any HTML.

Figure 2.6 provides an example of the final architecture of the MMIS with the main structure and design; basic components and characteristics, and access methodology

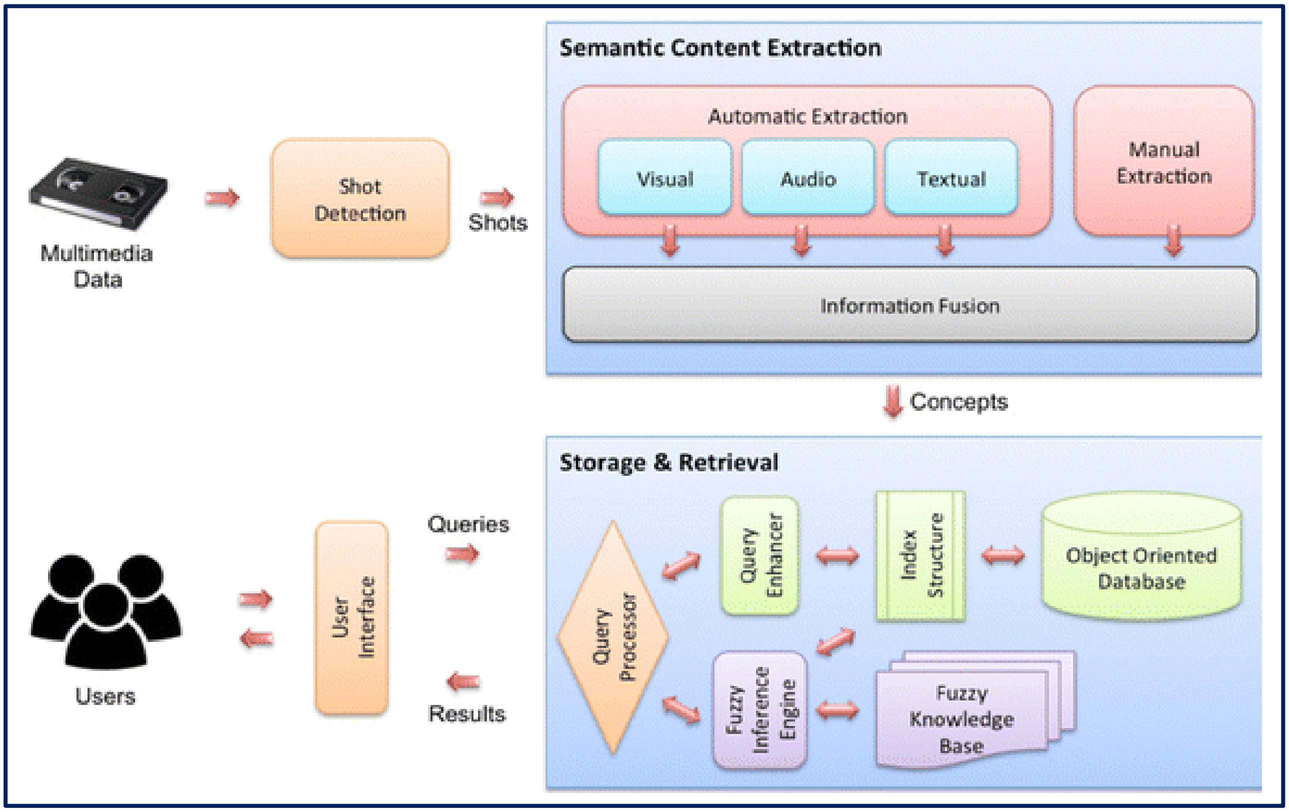


Figure 2.6: The Main Architecture of the MMIS

2.4.5 Phase Five: Testing

Multimedia product should be tested and evaluated by the users. By going through this testing, the developer can locate flaws ahead of time and repaired them before releasing the finished product. During the test the developer should consider the following points:

- Is it product to read (in case of descriptive text)?
- Is it user friendly?
- Is it interactive and easy to navigate?
- Is the final product match the actual requirements of the user

The final audience and the developer very often have different points of view. The developer must learn to regard problems the user detects with the program as constructive criticism. The reason testing is so valuable is that it is too easy to lose sight of the audience once the heavy duty authoring starts.

2.5 Participants in Multimedia Systems Development

In recent years, the World Wide Web has become the platform of popular choice for the deployment of multimedia applications. In its early days, Web development was the domain of a few enthusiastic individuals,—the self-styled, jack-of-all-trades 'Webmasters'. However, as Web technologies progressed rapidly and began to support interactive multimedia and dynamic applications, it became apparent that the skills required to design, develop, and support industrial strength Web-based systems were so diverse that no single individual could possibly possess them all. It is now generally acknowledged that the development of multimedia and Web-based systems is a collaborative activity that should properly involve an integrated team of specialists.

Naturally, the composition of a multimedia development team shall depend on the characteristics of the project at hand,—such as size, complexity, use of media components, and application type. Here, examples of the participants in multimedia systems development:

- **Animators/Graphic Designers**
- **Programmers/Software Engineers**
- **Systems Analysts/Designers**
- **Audio Producers**
- **Scriptwriters/Story-boarders**
- **Video Producers**
- **Localization/Technical writers**
- **Human Factors Engineers**

It is evident that Animation/Graphic Design, Programming/Software Engineering, Systems Analysis and Design, Audio Production, Scriptwriting/Storyboarding and Video Production are clearly defined activities in the multimedia development process. Of these, Animation/Graphic Design, Programming/Software Engineering, and Systems Analysis and Design are major roles to which, it would appear, professionally trained individuals are singly dedicated. For lesser roles, there is likely to be some overlap whereby, *for example*, Audio Production and Video Production might be performed by the same person. Interestingly, despite the widely acknowledged importance of usability in multimedia and Web-based systems development, the role of Human Factors Engineer features lowest in the ranking order.

Of course, skills diversity is not unique to multimedia systems development,—many conventional projects, particularly large ones, necessitate the integration of various knowledge domains. However, participants in traditional systems development tend to be primarily 'computer professionals', which is not the case with multimedia systems development. This has significant implications. Individuals from different environments perceive things differently,—a principal cause of human misunderstandings.

Misunderstandings are common in IS development, and are all the more likely in the development of multimedia systems. In particular, there are paradigmatic differences between Animators/Graphic Designers and Programmers/Software Engineers, whereby these two conflicting communities appear to operate in distinctively different worlds.

That, Animation/Graphic Design and Programming/Software Engineering are the two most significant roles in multimedia systems development highlights the importance of developing tools, techniques and approaches that aid the resolution of these critical communicational problems.

Furthermore, there are process management issues. The working arrangement between team members is highly interdependent and depending on each other’s skills. Traditional linear, black box, throw-it-over-the-wall methods are therefore inappropriate. Team members need to understand the goals, perspectives, and approaches of their colleagues, so that feasible and optimal design decisions are made. Methods that emphasize multidisciplinary collaboration are therefore needed.

2.6 The Complexity of a Multimedia Development Project

Multimedia applications are a representative example for the integration of modern ***hardware technology*** and ***advanced software techniques***. New technical devices support the physical processing, storage, communication, and rendering of various types of media. Most of these hardware components have related counterparts on the side of software, such as device drivers or supporting software subsystems. Together they form an appropriate foundation for advanced applications in complex, heterogeneous environments.

Besides these more formally and physically oriented characteristics, sophisticated application types show a strong requirement for conceptual structures and logical relations. Contrary to basic multimedia representation systems, integrated, content-oriented applications require a much larger effort for the integration of logical and physical objects. This dualism of form and content can be made evident, for example, by the comparison of multimedia and hypermedia where multimedia is the formal foundation, conceptually augmented by the logical content of hypertext and hypermedia.

The application development for a scenario, based on multimedia and hypermedia techniques, can be an expensive process with regard to various types of investments made in it. There is a strong need for distribution and reusability of physical and logical resources. These requirements can be satisfied in many respects by adopting the techniques offered by database systems and extending them to Multimedia Databases. Multimedia databases provide a means to store and manage objects, to define and preserve consistent logical relations, and finally, to distribute this synthesis of objects and knowledge to an open number of applications and users.

The core idea of multimedia systems is to handle information that requires various types of media to be expressed and accessed in an efficient way. It is, *for instance*, reasonable to claim that one key factor of increased public Internet use is a multimedia interface offered in web-browsers. Compared to text-based system, multimedia applications attract users by offering various types of media, *such as* graphics and sounds. However, that is usually not enough. There must be some content in the system that makes the system exciting to use.

Using the system is often presented as a challenge, where the user has to struggle with various problems to move on in the system. It is also common to create an interface representing an environment that the user has to investigate. The motivation to use the system is often excitement and interest, even if the goal of using the system may be learning or training. In order to gain these motivation effects in multimedia systems, substantial effort must be put into the creation of the system's content. It may, *for example*, concern embedded scenarios in order to make the system attractive and interesting to use.

In developing multimedia systems it has been common to create the major part of the content of the system before the system is taken into use. In order to create content, competencies are needed from various fields of practice, as the content is often of a graphical, narrative or other aesthetic nature. Since software engineers perhaps are not the best creators of aesthetic content they have to seek content providers in museums, publishing houses, television, and movie studios.

Therefore, here are some of the factors that can be considered as the main inhibitors of a successful multimedia development project that should be considered from the beginning of the development project:

- Staff shortages
- Inadequate staff skills

- Scope creep
- Unclear statement of requirements
- Unrealistic expectations
- Acquiring multimedia content
- Unexpected complexity of project
- Exceeding budgets
- Software testing and debugging
- Failing to meet project deadlines
- Lack of systems development techniques
- Inadequate design of the system

2.7 Applications of Multimedia Systems

Use of multimedia is common in many computer applications, because graphics, sounds, animations and video can often do a more effective job of involving the user than text alone. Examples of typical present multimedia applications include:

- Multimedia is a prerequisite of all kinds of games
- Computer-based training
- Dictionaries (Tells how to pronounce difficult word)
- Encyclopedias and On-line reference works (important sound and video clips)
- Business Presentations
- Web Applications
- Advertisement, etc.
- Digital video editing and production systems
- Electronic newspapers/magazines
- Home shopping
- Interactive TV
- Multimedia courseware
- Video conferencing
- Video-on-demand
- Interactive movies

Review Questions

Q1. To what extent the information system development process differs from the MMIS development process

Q2. A typical multimedia project is divided into a design phase and a development phase - Illustrate these comprising seven main activities.

Q3. Compare between the lifecycles of information systems and multimedia systems.

Q4. Developing multimedia information systems can be regarded as three parallel processes – Explain in details using the related figure these three processes.

Q5. Discuss briefly the suggested five phases of MSDLC for creating an effective MMIS.

Q6. Give some examples of multimedia software tools for each multimedia category.

Q7. What is meant by Multimedia Authoring? … Illustrate some examples of authoring programs.

Q8. Describe using the related figure the main architecture of the MMIS.

Q9. The composition of a multimedia development team shall depend on the characteristics of the project at hand, *such as*; …………., …………, ………., and …………. . [Complete]

Q10. Illustrate the main roles of the various participants in multimedia systems development team.

Q11. Discuss the factors that can be considered as the main inhibitors of a successful multimedia development project.

Q12. Explain from your point of view the main steps should be performed for creating an effective and perfect MMIS.

Q13. Give **(*at minimum seven*)** examples of typical present multimedia applications.

CHAPTER THREE

MULTIMEDIA DATABASES

Chapter Three

MULTIMEDIA DATABASES

3.1 Nature of Multimedia DataBase

Today we are in an information flood as computing and communication makes more information available than ever before. Hypermedia, multimedia and database technologies are powerful tools that facilitate information representation, access and management. Database systems need to do more than providing a document model or binary large objects to implement multimedia database systems. They need to incorporate the role of media servers which are extensions of traditional file servers with isochronous multimedia data delivery capabilities.

> Hence, A **Multimedia Database** (**MMDB**) can be defined as a collection of related multimedia data that represented, manipulated, and distributed within a specific information system for certain purpose.

The multimedia data include one or more primary media data types, *such as*; text, images, graphic objects (including drawings, sketches and illustrations) animation sequences, audio and video into a single unit. The composition and characteristics of multimedia data may be analyzed from several perspectives. These include information overload, inadequacy of textual descriptions, and multiplicity of data types, spatial and temporal characteristics, and huge volumes of data.

The integration of multimedia data types from multiple sources uniquely characterizes the multimedia information systems. The various data types may be found in a typical multimedia database include:

- **Text**;
- **Images**: color, black and white, photographs, maps, and paintings. Some issues of images are:
  - ◊ Is the image as high-quality as I need?
  - ◊ Is the image efficiently stored and transmitted?
  - ◊ Can the image be retrieved by its content?
- **Graphic Objects**: ordinary drawings, sketches, and illustrations, or 3D objects;
- **Animation Sequences**: images or graphic objects, (usually) independently generated;
- **Video**: also a sequence of images (called frames), but typically recording a real-life event and usually produced by a video recorder. Some issues of videos are:
  - ◊ How are the temporal relations between the media represented?
  - ◊ What do I need to stream video across the network?

◊ Are the different media synchronized?
◊ How can I describe a video retrieval request like a query?

- **Audio**: generated from an aural recording device; and

- **Composite Multimedia**: formed from a combination of two or more of the above data types, *such as*; an intermix of audio and video with a textual annotation.

Some multimedia data types *such as* video, audio and animation sequences also have temporal requirements, which have implications on their storage, manipulation, and presentation. The problems become more acute when various data types from possibly disparate sources must be presented within or at a given time. Similarly, images, graphics, and video data have spatial constraints in terms of their content. Usually, individual objects in an image or a video frame have some spatial relationship between them. Such relationships usually produce some constraints when searching for objects in a database.

These data types are broadly categorized into ***three classes***:

- ***Static Media*** (Discrete Data); the contents and meanings do not depend on the presentation time, Time-independent: alphanumeric data, image and graphic object.
- ***Dynamic Media*** (Continuous Data); the meanings and correctness depend on the rate at which they are presented, Time-dependent: audio, video and animation.
- ***Dimensional Media*** (3D game and computer aided drafting programs).

Continuous data are more complex than discrete data - demanding the use of much better compression/decompression algorithms and more sophisticated operations for their interpretation and manipulation

Comparison of Multimedia Data Types

Medium	Elements	Time-dependence
Text	Printable characters	No
Graphic	Vectors, regions	No
Image	Pixels	No
Audio	Sound, Volume	Yes
Video	Raster images, graphics	Yes

Huge volumes of data also characterize multimedia information. For instance, to store an uncompressed image of 1024 ¥ 728 pixels at 24 bits per pixel requires a storage capacity of about 2 Mbytes. With a 20:1 compression ratio, the storage requirement could be reduced to about 0.1 Mbyte. If we consider a video example, a 10-minute sequence of the same image at 30 frames per second requires about 38,000 Mbytes of storage, reducible to about 380 Mbytes with a compression ratio of 100:1. The potential for huge volumes of data involved in multimedia information systems become apparent when you consider that a movie could run as long as two hours, and a typical video repository would house thousands of movies.

An old adage says that "*a picture is worth more than a thousand words*". However, representing multimedia information as pictures or image sequences poses some problems for information retrieval due to the limitations of textual descriptions of a multimedia experience and the massive information available from it. The potential information overload means that users may find it difficult to make precise requests during information retrieval. The limitations of textual descriptions also imply the need for content-based access to multimedia information. Users need multiple cues (*such as* shape, color, and texture) that are relevant to the multimedia content.

Another characteristic of multimedia information is that interaction with such information types usually involves long-duration operations (*such as* with video data), and sometimes, with more than a single user (as is typical in collaborative support environments). However, in collaborative environments, it is expected that most multimedia data are likely to be accessed in a read-only mode. This assumption can be used to facilitate the provision of concurrency control algorithms.

Additionally, a MMDB needs to manage additional information pertaining to the actual multimedia data. The information is about the following:

- **Media Data:** the actual data representing an object.
- **Media Format Data:** information about the format of the media data after it goes through the acquisition, processing, and encoding phases.
- **Media Keyword Data:** the keyword descriptions, usually relating to the generation of the media data.
- **Media Feature Data:** content dependent data such as contain information about the distribution of colours, the kinds of textures and the different shapes present in an image.

The last three types are called metadata as they describe several different aspects of the media data. The media keyword data and media feature data are used as indices for searching purpose. The media format data is used to present the retrieved information.

Multimedia data management support in enterprise environments requires more than just media servers. There are more features and functions required than simply the ability to store and deliver multimedia information. There are many features that the database system can provide. Prior to database systems, the file system was the common component. Database systems actually utilize file systems and add additional functionality. Database system structures like indexes, catalogs, dictionaries are stored using file systems. The database system extends the file system's management capability.

A similar architectural hierarchy exists between multimedia database systems and media servers as shown in Figure 3.1. The media server provides basic level storage and delivery control.

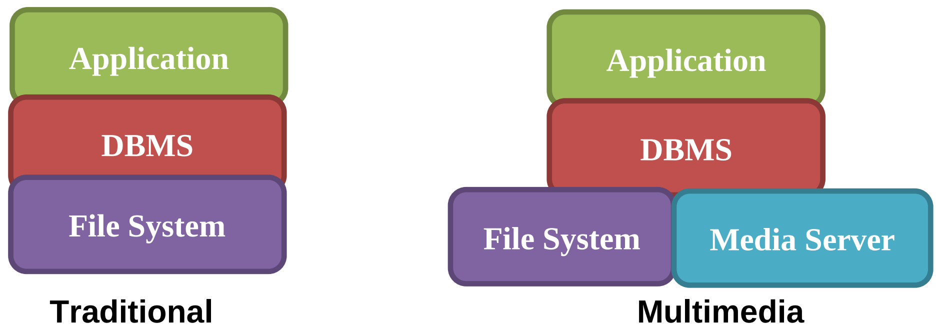


Figure 3.1: Database System Environment

The database system adds features and functions described in the previous sections to these basic capabilities. Multimedia database systems need to support a variety of features as stated in the following list:

- Native support of multimedia data types
- Ability to create a model of real world
- Temporal and spatial modeling
- Presentation ability
- Multimedia transactions
- Hierarchical storage management
- Storage, retrieval, and delivery

3.2 Multimedia Data Base Management System

The database management system basically offers a consistent data model, a consistent user interface, and a set of tools for managing the storage and retrieval of the multimedia data.

> A **Multimedia Database Management System (**A **Multimedia DBMS)** is a framework that manages different types of data potentially represented in a wide diversity of formats on a wide array of media sources. It provides support for multimedia data types, and facilitate for creation, storage, access, query and control of a multimedia database.

A multimedia DBMS provides a suitable environment for using and managing multimedia database information. Therefore, it must support the various multimedia data types, in addition to providing facilities for traditional DBMS functions ***like*** database definition and creation, data retrieval, data access and organization, data independence, privacy, integration, integrity control, version control, and concurrency support.

The functions of a multimedia DBMS basically resemble those of a traditional DMBS. However, the nature of multimedia information makes new demands—including determining what is needed and how to provide that functionality.

Using the general functions provided by a traditional DBMS as a guide, we can describe the purposes of a multimedia DBMS as follows:

- ***Integration***. Ensures that data items need not be duplicated during different program invocations requiring the data.
- ***Data Independence.*** Separation of the database and the management functions from the application programs.
- ***Concurrency Control.*** Ensures multimedia database consistency through rules, which usually impose some form of execution order on concurrent transactions.
- ***Persistence***. The ability of data objects to persist (survive) through different transactions and program invocations.
- ***Privacy***. Restricts unauthorized access and modification of stored data.
- ***Integrity Control***. Ensures consistency of the database state from one transaction to another through constraints imposed on transactions.
- ***Recovery***. Methods needed to ensure that results of transactions that fail do not affect the persistent data storage.
- ***Query Support***. Ensures that the query mechanisms are suited for multimedia data.
- ***Version Control***. Organization and management of different versions of persistent objects, which might be required by applications.

In concurrency control, a transaction is a sequence of instructions executed either completely or not at all. In the latter case, the database is restored to its previous state. Defining the appropriate granularity for concurrency is a problem in multimedia databases. Traditional databases use a single record or table as the unit of concurrency; multimedia databases typically use a single object (or composite object) as the logical unit of access. Thus the single multimedia object could form the unit of concurrency.

In achieving persistence, a simple method is to store the multimedia files in some operating system files. However, the huge data volumes make this approach costly to implement. Moreover, the system also needs to store the multimedia metadata and possibly composite multimedia objects. Thus, most multimedia DBMSs classify the data as either persistent or transient and store only persistent data after transaction updates. Temporary data are used only during program or transaction execution and are removed afterwards.

Traditionally, a query selects a subset of the data objects based on the user's description (usually some form of query language) of what data to access. A query usually involves various attributes, possibly keyword-based or content-oriented, and is usually interactive. Thus, functions for relevance feedback and query formulation, similarity (rather than exact) matches, and mechanisms for displaying ranked results are important in a multimedia DBMS.

Version control becomes important when a persistent multimedia object is updated or modified, as some applications might need to access previous states of the object. A DBMS provides such access through versions of the persistent objects. For a multimedia DBMS, the huge volumes of data reinforce the importance of efficiently organizing such versions. Moreover, the available storage might limit the provision of versions. In addition, version management may involve not only versions of single objects, but also versions of the complex objects that make up the multimedia database.

The special nature of multimedia data also makes it important to support new special functions. These include object composition and decomposition, management of huge volumes of multimedia data, effective storage management, and information retrieval and handling of spatial and temporal data objects.

Multimedia databases should have the ability to uniformly query data (media data, textual data) represented in different formats and have the ability to simultaneously query different media sources and conduct classical database operations across them. ***(Query and Retrieval Support)***

They should have the ability to retrieve media objects from a local storage device in a good manner. ***(Storage Support)***

They should have the ability to take the response generated by a query and develop a presentation of that response in terms of audio-visual media and have the ability to deliver this presentation. ***(Presentation and Delivery Support)***

3.3 Requirements for Multimedia DBMS

For the multimedia DBMS; in order to serve its expected purposes, it must meet certain special requirements. Figure 3.2 describes a multimedia DBMS architecture and the interaction of the different components needed to provide the services expected. The requirements are divided into the following broad categories:

- Traditional DBMS capabilities
- Huge capacity storage management
- Information retrieval capabilities
- Media integration, composition, and presentation
- Multimedia query support
- Multimedia interface and interactivity
- Performance

In addressing these requirements when building a multimedia database system, one must also address several other questions to achieve full functionality, including:

- How to build a multimedia database system that encompasses several application domains (that is not restrictive in terms of its domain applicability)?
- What are the levels of granularity for information decomposition, storage, and management? And how the underlying techniques and structures can be mapped and used on the units of data?
- Knowing the data compositions of a multimedia database, how can one reliably and efficiently develop a query language that supports the myriad access methods associated with and necessary for the diverse object types? How will the query language support the multimedia data's different characteristics and morphologies?
- What kind of presentation infrastructure will the multimedia system have to accommodate the diverse presentation, requirements and modes for the different multimedia data? How can one synchronize presentations to support the temporal and spatial requirements of the different multimedia data?
- Given that different media types have differing modification and update requirements, how will the system update different components of the multimedia session? What levels of granularity will those updates have?

Figure 3.2 shows a sample high-level architecture for a multimedia DBMS that addresses some of the requirements that have been discussed. This configuration includes most of the management modules associated with a traditional DBMS. In addition, it contains some of the modules that are required specifically for multimedia data management, such as the media integrator and object manager.

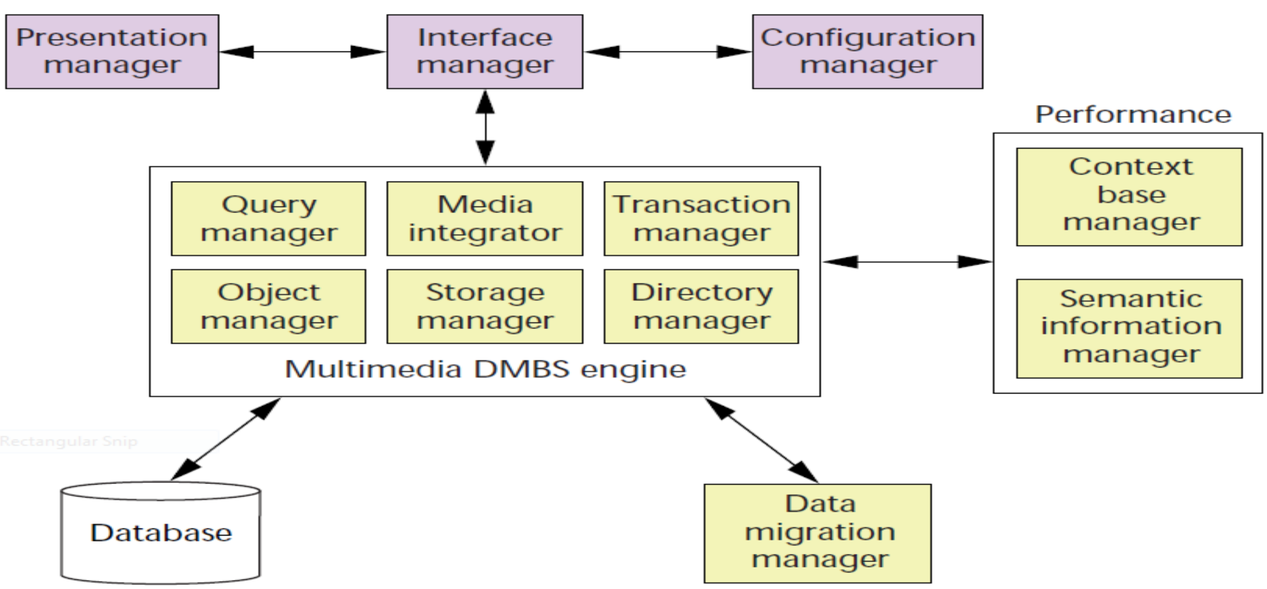


Figure 3.2: A high-level architecture for a multimedia DBMS that meets the requirements for multimedia data.

However, most of the additions to the traditional DBMS are external to the core of the multimedia DBMS. These include the presentation, interface, and configuration managers. The configuration also includes a context-base and semantic information manager, which are part of the performance module.

3.3.1 Huge Capacity Storage Management

The storage requirements in multimedia systems can be characterized by their huge capacities and the storage system's hierarchical (pyramidal) organization (see Figure 3.3). Hierarchical storage places the multimedia data objects in a hierarchy of devices, either online, near-line, or offline. In general, the highest level provides the highest performance, highest cost, smallest storage capacity, and least permanence. Note, however, that permanence improves—at significant additional cost—with the use of nonvolatile random access memory.

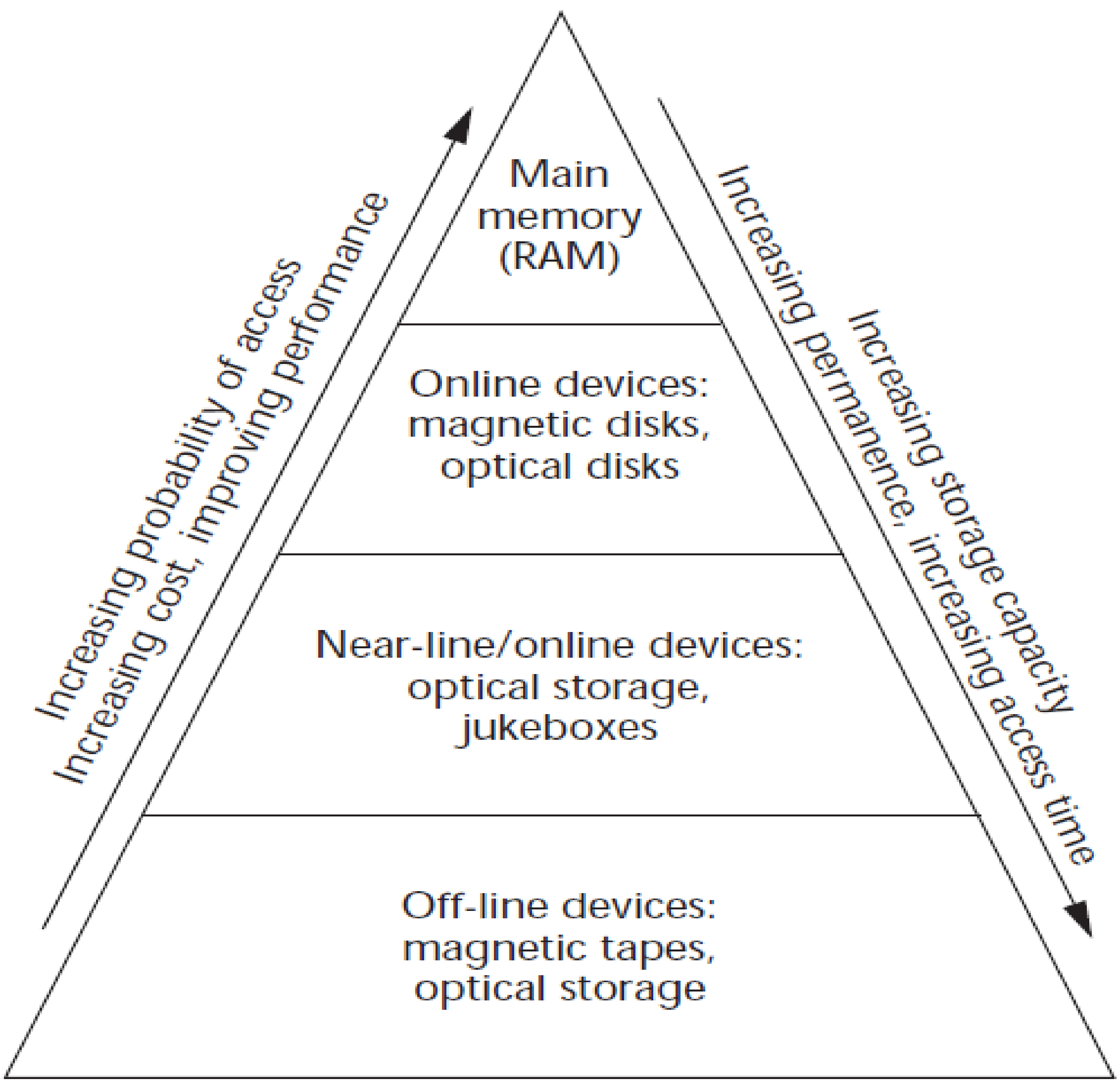


Figure 3.3: Hierarchically Organized Storage for Multimedia Databases.

Another unique use of this hierarchical storage organization is that the higher levels of the hierarchy can be used to store smaller abstractions (or representations) of the actual multimedia data, which can be used to facilitate faster browsing and previewing of the database content.

Cost and performance (in terms of access time) decrease as we go down the hierarchy (pyramid), while storage capacity and permanence increase. Typically, in most multimedia storage systems the highest level of storage is (volatile) random access memory, followed by magnetic disk drives. These provide online services. Optical storage devices provide the next level of storage. Online in some cases, they are near-line (like jukeboxes) in most cases. The lowest level in the storage hierarchy represents offline storage devices, including magnetic tapes, optical disks, and so forth. These may or may not be directly connected to the computer. They offer the highest storage capacity and permanence but provide the least performance in terms of access time.

A multimedia DBMS must therefore manage and organize multimedia data stored at any level in the hierarchy. It must have mechanisms for automatically migrating multimedia data objects from one level of the storage hierarchy to another. A detailed treatment of these migration policies exceeds our scope here, but they must be based on some clearly defined criteria *such as* frequency of use. In general, even when the data is stored in offline storage devices, the multimedia DBMS should have information on how to easily locate the specific device containing the multimedia data being sorted.

Data migration in multilayered storage systems is not unusual to multimedia DBMSs. All databases handling huge amounts of data must address this issue. The interconnection between the memory systems is obviously a problem, especially when a multimedia database involves distributed sources of data. As a result, the problem of data migration may require the consideration of other network related issues, such as data availability rates, bandwidth limitations, and network delays.

3.3.2 Media Integration, composition, and Presentation

Given the multiplicity of data types supported, the multimedia DBMS should also provide facilities for integrating data items (from possibly disparate media types) to form new composite multimedia types and for presenting such data at a given site within the required time frame. Multimedia integration, composition, and presentation are exacerbated by the often continuous (temporal) nature of multimedia data—especially video, animation, and audio. Moreover, certain applications, *such as* geographic information systems, may require a multimedia DBMS to address spatial information. All these factors put together make multimedia composition and presentation a complex process that the multimedia DBMS must support to meet the diverse user community's needs.

The integration problem can be enhanced in some cases, especially where the multimedia database system is tailored to the requirements of some target user community. In such special cases the multimedia DBMS could support specific features not needed for other applications.

3.3.3 Multimedia Interface and Interactivity

The diverse nature of multimedia data calls for an equally diverse interface for interacting with the database. Typically, each media data type has its own method for access and presentation. *For instance*, video and audio data will need different user interfaces for presentation and query. For some multimedia applications, especially those involving continuous media, the user often expects the interactive facilities of a VCR or tape recorder, *such as* fast forward and reverse. When a multimedia system provides such services, it has implications for the database, especially retrieval of the needed multimedia objects, their integration, and their synchronization. Thus the multimedia DBMS might need to support such forms of interactivity.

3.3.4 Performance

Efficiency is an important consideration in a multimedia DBMS. Multimedia database systems make new performance demands on media access, storage, indexing, retrieval, and query optimization. The different data types involved in multimedia databases might also require special methods for optimal storage, access, indexing, and retrieval. Rodriguez4 discusses some of the performance requirements that must be considered for multimedia DBMSs. These include efficiency, reliability, real-time execution, guaranteed and synchronized delivery of multimedia presentations, and quality-of-service (QoS) acceptable to the users. We will further discuss some of the issues affecting performance later.

3.3.5 Multimedia Data Modeling

Data models are central to multimedia database systems. A data model must isolate users from the details of storage device management and storage structures. It requires the development of appropriate data models to organize the various data types typically found in a multimedia database system.

Multimedia data models (just like traditional data models) capture the static and dynamic properties of the database contents, and thus provide a formal basis for developing the appropriate tools needed in using the multimedia data. The static properties could include the objects that make up the multimedia data, the relationships between the objects, the object attributes, and so on. Examples of the dynamic properties include interaction between objects, operations on objects, user interaction, and so forth.

However, the unique nature of multimedia data requires certain new considerations when choosing the data model. For instance, some multimedia data types (such as video) or group of types (example, video and images) might require special data models for improved modeling efficiency and flexibility. Moreover, the importance of interactivity in multimedia systems makes their support by the data model an important issue. Furthermore, it may be necessary to consider new integrity constraints in the context of multimedia databases.

Various data models, such as network, relational, semantic, and object-oriented models already exist for traditional databases, and a few have been proposed for multimedia databases. Two basic approaches have been used in modeling multimedia data.

- **The first** involves building a multimedia data model on top of an underlying traditional database data model (usually relational or object-oriented databases) by using appropriate interfaces for the multimedia data. The problem with this approach is that the underlying structures are not designed for multimedia data. Often, the significant differences between the requirements of the traditional and multimedia data make the interface a bottleneck in the overall system.
- These problems led to **the second method**, which decides to develop true multimedia-specific data models from scratch, rather than on top of an existing traditional database system. Nonetheless, a consensus almost exists that such efforts should be based on object-oriented techniques.

Current issues include developing appropriate data models for individual multimedia data types (such as video, images, or visual data), uniform modeling of arbitrary data types, and supporting huge volumes of multimedia data, multimedia interactivity, and content-based information using these models. Some authors have gone so far as to claim that the data model for a multimedia DBMS can only be fully achieved by object-oriented technology.

3.3.6 Multimedia Object Storage

Physically storing multimedia data requires methods for transforming, managing, transferring, and distributing huge volumes of data. Typical multimedia systems use a hierarchy of storage devices. Online high-speed devices (*such as* random access memories) and magnetic disks store multimedia data currently being used, while offline, low-speed devices (like optical storage and tapes) store long-term archival data. Performance then depends on the efficiency of the migration mechanisms used to assign the multimedia data items to the optimal level in the storage hierarchy.

Data compression schemes, in combination with the data transformation, help to reduce the huge capacity requirements. The basic method here is to transform the multimedia data to some transform space to remove the redundancies in the original data. Coding schemes code the transformed data for storage or transmission. Decompression is accomplished from the reverse process of decoding and re-transforming the data into its original form. This process often involves some loss of data, which a majority of multimedia applications can tolerate.

The huge volumes of data often involved and the constraints certain multimedia data types impose on the presentation make multimedia object storage a major consideration in database issues. Depending on the level of granularity, a multimedia object can represent the entire video sequence for a movie, a subsequence from the video, a single frame or image, or even individual objects in the image or video frame.

The major issues here are the limited available storage, the bandwidth limits of the storage system and communication channel, and the multimedia data type's availability rates. The data availability rate indicates the minimum amount of data required per unit time to meet acceptable levels of quality during presentation of the multimedia object. Viewed from this standpoint, multimedia data's storage requirements are most susceptible to decomposing the data into smaller multimedia objects. Each smaller object can be stored in the smaller available storage units.

As a necessary condition for storage allocation, at presentation time the data from the different storage units, when combined together, meet the data availability rates of the given multimedia data type. With the hierarchical storage arrangement, multimedia objects can be stored at different levels. As the utility rate of multimedia data objects changes, such objects will need to be reallocated, possibly to different storage devices on different levels of the storage hierarchy. The problems then involve finding optimal methods for multimedia object decomposition, allocation, and reallocation.

3.3.7 Multimedia Integration, Presentation, and QoS

Unlike traditional data, multimedia data have presentation constraints. These mainly result from the continuous nature of some multimedia data types, which requires presenting certain amounts of data within a given time for the presentation to seem natural to the user. When multimedia data are distributed and transported over networks, the problems of presentation become even more acute. Here, one can easily experience network problems, *such as* limited bandwidth and statistical network delays.

Continuous media by definition are time dependent, so timing becomes an important factor in their delivery and presentation. Therefore, in multimedia DBMSs the response to a query is often judged by both the correctness and the quality of the retrieved results.

From the user's point of view, the QoS parameter specifies, qualitatively, the acceptable levels of performance for the various services provided by the multimedia system and may affect the results of the multimedia presentation. Thus, to support multimedia presentations where a user can specify various QoS levels for different services, the multimedia DBMS must support the specified QoS levels and a QoS management service. This typically involves providing an appropriate mapping from the user's QoS to the system's QoS and vice versa.

When presenting different types of multimedia data—such as video and audio—together, problems of media integration and synchronization also become important. The multimedia DBMS must provide a mechanism to ensure good synchronization of the presented data while still meeting other requirements such as the data availability rates and the QoS. In some situations, the multimedia DBMS may have to rely on an explicit synchronization manager to ensure synchronization within a given data type and between different data types.

3.4 The Design Issues of the Multimedia Database

The multimedia data is not protected from unauthorized access. So, to provide for these security issues possible measures should been taken e.g. Data Analysis, Storage Management and Data Integrity should be checked to see how much the data in multimedia database is secure. While doing Data Analysis, Meta data management has to be done in order to do pattern matching. For Storage Management, the issues to be handled are access criteria for multimedia data types, and special index development. Data integrity checking includes maintenance of data by sustaining data quality, controlling concurrency, and multimedia updates recovery.

To keep multimedia databases secure and safe; is a difficult process *e.g.* command and control applications. In order to have a system secure completely and end to end security is needed i.e. there should be 100% secure multimedia database management system, secure networks, secure middle wares, and secure applications. A comprehensive structure of Multimedia database information system has been shown in Figure 3.4 which depicts the flow of Multimedia data objects while processing.

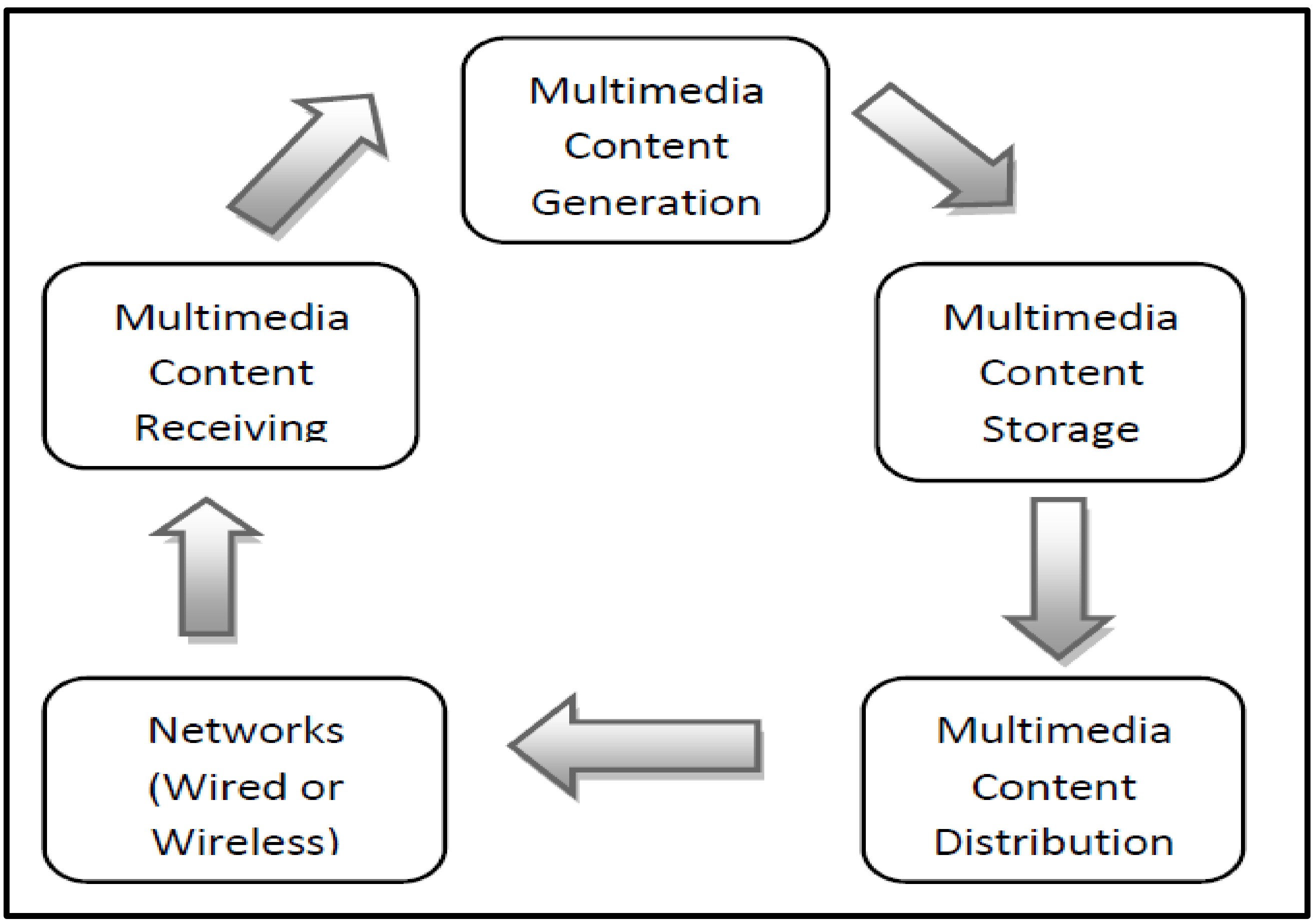


Figure 3.4: A Generalized Architecture of Multimedia Database Information System

For conventional text-based information processing, activities like data storage, access, manipulation, etc., have advanced considerably; however, for systems that incorporate multifarious data *such as*; continuous media data, those activities pose novel problems. The main issues which multimedia database researchers/designers need to face include, but not limited to:

- Development of sophisticated multimedia database conceptual models,
- Design of multimedia database query and retrieval languages,
- Design of powerful indexing and organization techniques,
- Development of efficient storage layout models to manage real-time multimedia data,
- Development of efficient and reliable retrieval and delivery strategies, and
- Development of flexible, adaptive, and reliable presentation techniques.

3.5 Challenges of Multimedia DataBase Systems

It is unarguably evident that the advent of Multimedia Information Systems (MMIS) has extremely and irreversible changed our technological landscape. MMIS encompasses the integrated generation, representation, storage, retrieval, processing, transmission, and presentation of dependent and independent data that are expressed in multifarious time dependent and independent media. Over the years, several technological approaches have been utilized to realize some form of Multimedia information systems.

One of the main requirements of multimedia database systems is that they will need data models more powerful and more versatile than the relational model, without compromising the advantages of the former. The relational data model exhibits limitations in terms of complex object management, indexing and content-based retrieval of video/image data, and facility for handling the spatiotemporal dimensions of objects.

However, past and present experience indicates that in order to adequately, sufficiently, and meaningfully addresses the capabilities of MMIS, Multimedia Data Base Systems (MMDBS) have to be designed and developed. Here are some issues and challenges related to the MMDBS:

- Multimedia data consists of a variety of media formats or file representations including TIFF, BMP, PPT, IVUE, FPX, JPEG, MPEG, AVI, MID, WAV, DOC, GIF, EPS, PN G, etc. Because of restrictions on the conversion from one format to the other, the use of the data in a specific format has been limited as well. Usually, the data size of multimedia is large such as video; therefore, multimedia data often require a large storage.
- Multimedia database consume a lot of processing time, as well as bandwidth.
- Some multimedia data types *such as* video, audio, and animation sequences have temporal requirements that have implications on their storage, manipulation and presentation, but images, video and graphics data have spatial constraints in terms of their content.

3.6 Application Areas of Multimedia DBMSs

In general, multimedia database management systems applications can be found wherever there is a need to manage multimedia data cost effectively. Thus multimedia DBMSs have found applications in such diverse areas as **Education** (digital libraries, training, presentation, distance learning), **Healthcare** (telemedicine, health information management, medical image systems), **Entertainment** (video-on-demand, music databases, interactive TV), **Information Dissemination** (news-on-demand, advertising, TV broadcasting), and **Manufacturing** (distributed manufacturing, distributed collaborative authoring). **Other areas** may include finance, video conferencing, electronic publishing, electronic commerce, and geographic information systems.

A number of multimedia DBMSs already exist. Most are extensions from existing object-oriented or relational DBMSs. The capabilities of existing multimedia DBMSs can be evaluated by the extent to which they support different media types (especially image and video). They can also be evaluated by their ability to support special functionalities required of a database system to manage multimedia data, such as real-time delivery and content based query and retrieval. Examples of multimedia database application areas can be described as the following:

- ### Digital Libraries

  A **digital library** is a special library with a collection of digital objects that can include text, visual material, audio material, video material, stored as electronic media formats (as opposed to print, or other media), along with means for organizing, storing, and retrieving the files and media contained in the library collection. Digital libraries can vary immensely in size and scope, and can be maintained by individuals, organizations, or affiliated with established physical library buildings or institutions, or with academic institutions. The digital content may be stored locally, or accessed remotely via computer networks. An electronic library is a type of information retrieval system. These information retrieval systems are able to exchange information with each other through interoperability and sustainability

- ### News-on-Demand

  One compelling application of the Informedia Digital Video Library is the indexing and retrieval of television, radio and text news. Currently, the TV and radio news is broadcast at a particular time, and if a person is not in front of a TV or radio at that time, the information becomes virtually inaccessible. Even if the news from different networks is taped on a VCR, there is rarely enough time to scan through tapes of yesterday's news for news stories relevant to a viewer's interest.

  With traditional media, the viewer/listener must watch or listen to all stories in a news show, without the ability to select which stories to skip and which stories to pursue in more detail. Furthermore, a person can only attend to one news channel at a time. Similar or related information broadcast on another news channel at the same time cannot be viewed. In contrast, text news from newspapers and news-wire services or even from broadcast transcripts is available in overwhelming quantities but cannot provide the comprehensive visual and audio information available in the original radio and video material.

A technology that brings personalized news to cable television or Internetsubscribers by indexin g and searching video and audio material by text content. News-on-Demand system is an innovative example of indexing and searching broadcast video and audio material by text content. News-on-Demand is a fully-automatic system that monitors TV, radio and text news and allows selective retrieval of news stories based on spoken queries. The user may choose among the retrieved stories and play back the news stories of interest. The system runs on a Pentium PC using MPEG-I video compression. Speech recognition is done on a separate platform using the Sphinx-II continuous speech recognition system.

Two distinct phases are included in the Informedia News-On-Demand process: library creation and library exploration. Library creation deals with the accumulation of information, transcription, segmentation and indexing. Library exploration concerns the interaction between the system and the user trying to retrieve selections in the database.

- **Video-on-Demand**

Video on demand **(VOD)** are systems which allow users to select and watch/listen to video or audio content such as movies and TV shows when they choose to, rather than having to watch at a specific broadcast time, which was the prevalent approach with over-the-air broadcasting during much of the 20th century. IPTV technology is often used to bring VOD to televisions and personal computers.

Television VOD systems can either "stream" content through a set-top box, a computer or other device, allowing viewing in real time, or download it to a device such as a computer, digital video recorder (also called a personal video recorder) or portable media player for viewing at any time. The majority of cable- and telephone company-based television providers offer both VOD streaming, free content, whereby a user buys or selects a movie or television program and it begins to play on the television set almost instantaneously, or downloading to a digital video recorder (DVR) rented or purchased from the provider, or downloaded onto a PC or to a portable device, for viewing in the future. Internet television, using the Internet, is an increasingly popular form of video on demand. VOD can also be accessed via desktop client applications such as the Apple iTunes online content store.

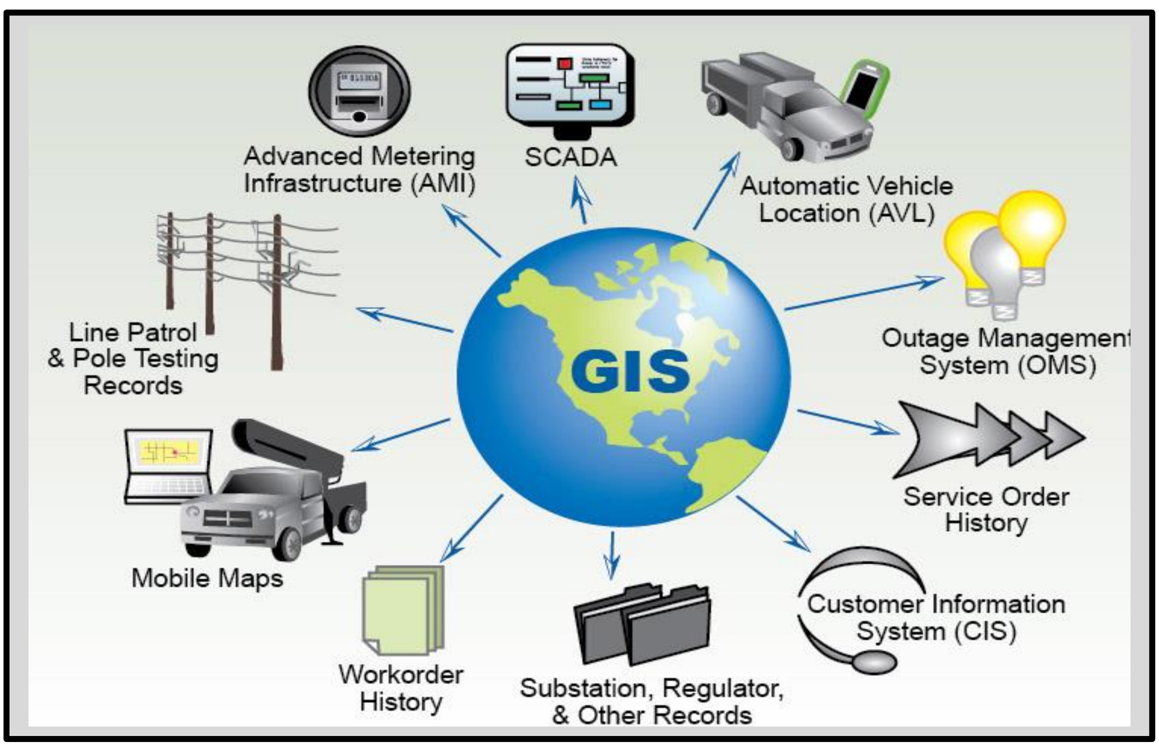
Some airlines offer VOD as in-flight entertainment to passengers through individually controlled video screens embedded in seatback so or armrests or offered via portable media players. Some video on demand services, *such as* **Netflix**, use a subscription model that requires users to pay a monthly fee to access a bundled set of content, which is mainly movies and TV shows. Other services use an advertising-based model, where access is free.

- ## Music Database

Music-on-demand is a music distribution model considered with the growth of two-way computing, telecommunications and the Internet in the early 1990s. Primarily, high-quality music is made available to purchase, access and play back using software on the Apple Macintosh, Microsoft Windows, set-top boxes and mobile devices from an available distribution point, such as a computer host or server located at a telephone, cable TV or wireless data center facility.

- ## Geographic Information Systems (GIS)

The latest advances in computer industry especially in hardware has led to the development of the Multimedia and Geographical Information System (GIS) technologies. Multimedia provides communications using text, graphics, animation, and video. The combination of several media often results in a powerful and richer presentation of information and ideas to stimulate interest and enhance information retention. GIS is a powerful set of tools for collecting, storing, retrieving, transforming, managing, analyzing, and displaying spatial data. The integration of those technologies will improve the services offered to the tourism market.



GIS and Multimedia for the Tourism Industry

One of the problems encountered in the tourism industry is the quick update and maintenance of the data. Data concerning geographical beauties, culture heritage, monuments, hotels, amusement parks, and so on are continuously collected by local tourism authorities. The current procedures for publishing those data are not on line with the need of a prompt usage of the data themselves. They are in fact made available through traditional channels like booklets, brochures and so forth. Using Multimedia and GIS in the tourism-oriented application market will make it possible to deliver those data also in electronic formats using new media like CD-ROM. However, any necessary update of the data requires, today, a new delivery. This introduces extra costs that can be avoided with the availability of Multimedia database managed locally and available, through Internet, to the application developers.

Combining these two technologies will allow the final user of tourist applications:

- to provide new classes of functionalities based on vector data (route optimization, adjancy, proximity calculus, etc.) in addition to the multimedia functionalities,
- to provide an authoring system for supporting the automatic generation of a wide spectrum of tourism applications based on Multimedia and GIS technology, and
- to develop a Multimedia/GIS distributed database.

• Telemedicine

Telemedicine is the use of telecommunication and multimedia information technology to provide clinical health care from a distance. It has been used to overcome distance barriers and to improve access to medical services that would often not be consistently available in distant rural communities. It is also used to save lives in critical care and emergency situations.

Although there were distant precursors to telemedicine, it is essentially a product of 20th century telecommunication and information technologies. These technologies permit communications between patient and medical staff with both convenience and fidelity, as well as the transmission of medical, imaging and health informatics data from one site to another.

Early forms of telemedicine achieved with telephone and radio have been supplemented with video telephony, advanced diagnostic methods supported by distributed client/server applications, and additionally with tele-medical devices to support in-home care.

Review Questions

Q1. What is meant by Multimedia Database? How does it differ from the traditional Database?

Q2. Describe the various data types that may be found in a typical multimedia database.

Q3. The data types are broadly categorized into ***three classes*** … What are these three classes?

Q4. What is meant by the metadata? Give examples for that information for the media data.

Q5. Multimedia database systems need to support a variety of features such as; ………, ……….., …………, …………..., ……………..., ……………, ……………. .

Q6. Discuss the concept of the multimedia DBMS.

Q7. Illustrate in details the main purposes of a multimedia DBMS.

Q8. What are the categories of the requirements for the multimedia DBMS?

Q9. Discuss in details (using the related figure) the hierarchical storage requirements in multimedia systems**.**

Q10. Discuss the two basic approaches that have been used in modeling multimedia data.

Q11. What are the main issues which multimedia database researchers/designers need to face and deal with?

Q12. Illustrate in details ***three*** examples of multimedia database application areas.

Q13. Describe how efficiently the GIS and Multimedia can be used for the Tourism Industry

Chapter Four

Multimedia Information Retrieval

Chapter Four

Multimedia Information Retrieval

4.1 Introduction

Living in the information era, there are enormous amount of digital content. The estimated size of newly created digital data in 2011 was about 1,800 exabytes (1 exabyte = 1 billion gigabytes), roughly 700 times more than the production in 2002 (2–3 exabytes). This number is equivalent to a ten-fold average annual growth rate. In terms of image and video content, according to the latest released statistics, YouTube hosts more than 120 million copyright claimed videos and serves four billion video requests per day. On the other hand, Facebook hosts more than 50 billion photos (2010), 15 billion of which are tagged. Another statistic shows that Facebook had 845 million monthly active users and 483 million daily active users on average in December 2011. Undoubtedly, digital content, including images and videos, are deeply rooted in our daily life, served on a wide range of devices, from desktops and laptops to mobile phones and tablets. Large-scale content-based multimedia data organization and analysis not only helps to retrieve users' desired information, but also serves as the basis for multimedia applications such as classification and retrieval of images/videos, scientific images, film, motion data, as well as the recent explosion of cross-platform mobile visual search and recommendations.

Finding information in a multimedia archive is a notoriously difficult task due to the semantic gap. Therefore, the user and the system should support each other in finding the required information. Interaction of users with a data set has been studied most thoroughly in categorical information retrieval. The techniques reported there need rethinking when used for image retrieval as the meaning of an image, due to the semantic gap, can only be defined in context. Multimedia retrieval requires active participation of the user to a much higher degree than required by categorized querying. In content-based image retrieval, interaction is a complex relationship between the user, the images, and their semantic interpretations.

Multimedia databases are becoming more and more common, allowing users to store and retrieve various media for different purposes. Medical researchers are storing x-rays in medical image databases, art historians are archiving and documenting artwork, geographers are creating geographical information systems, and digital libraries are becoming more popular. The storage of various media in multimedia databases poses new challenges to query techniques - challenges that exceed the expressive power of traditional text-based query languages. New query interfaces should take advantage of characteristics inherent in multimedia data, such as the dynamic temporal nature of video, the visual and spatial characteristics of images, the pitch of audio, etc. MMISs with effective content retrieval will have wide application in industry, medicine, education and the military.

4.2 Multimedia Information Retrieval

Multimedia Information Retrieval (**MMIR** or **MIR**) is a research discipline of computer science that aims at extracting semantic information from multimedia data sources. Data sources include directly perceivable media such as audio, image and video, indirectly perceivable sources *such as* text, bio-signals as well as not perceivable sources *such as* bioinformation, stock prices, etc. The methodology of MMIR can be organized in three groups:

1. Methods for the summarization of media content (Feature Extraction). The result of feature extraction is a description.
2. Methods for the filtering of media descriptions (*for example*, elimination of redundancy)
3. Methods for the categorization of media descriptions into classes.

4.2.1 Feature Extraction Methods

Feature extraction is motivated by the complete size of multimedia objects as well as their redundancy and, possibly, noisiness. Generally, two possible goals can be achieved by feature extraction:

- **Summarization of Media Content.** Methods for summarization include in the audio domain, *for example*, mel-frequency cepstral coefficients, Zero Crossings Rate, Short-Time Energy. In the visual domain, color histograms, *such as* the MPEG-7 Scalable Color Descriptor can be used for summarization.
- **Detection of Patterns** by auto-correlation and/or cross-correlation. Patterns are recurring media chunks that can either be detected by comparing chunks over the media dimensions (time, space, etc.) or comparing media chunks to templates (e.g. face templates, phrases). Typical methods include Linear Predictive Coding in the audio/bio-signal domain, texture description in the visual domain and n-grams in text information retrieval.

4.2.2 Merging and Filtering Methods

Multimedia Information Retrieval implies that multiple channels are employed for the understanding of media content. Each of these channels is described by media-specific feature transformations. The resulting descriptions must be merged to one description per media object. Merging can be performed by simple concatenation if the descriptions are of fixed size. Variable-sized descriptions – as they frequently occur in motion description – must be normalized to a fixed length first.

Frequently used methods for description filtering include factor analysis (e.g. by PCA), singular value decomposition (e.g. as latent semantic indexing in text retrieval) and the extraction and testing of statistical moments. Advanced concepts *such as* the Kalman filter are used for merging of descriptions.

4.2.3 Categorization Methods

Generally, all forms of machine learning can be employed for the categorization of multimedia descriptions though some methods are more frequently used in one area than another. For example, hidden Markov models are state-of-the-art in speech recognition, while dynamic time warping – a semantically related method – is state-of-the-art in gene sequence alignment. The list of applicable classifiers includes the following:

- Metric approaches (Cluster Analysis, Vector Space Model, Minkowski Distances, Dynamic Alignment)
- Nearest Neighbor methods (K-nearest neighbors algorithm, K-means, self-organizing map)
- Risk Minimization (Support Vector Regression, Support Vector Machine, linear Discriminant Analysis)
- Density-based Methods (Bayes Nets, Markov Processes, Mixture Models)
- Neural Networks (Perceptron, Associative Memories, Spiking Nets)
- Heuristics (Decision Trees, Random Forests, etc.)

The selection of the best classifier for a given problem (test set with descriptions and class labels, so-called ground truth) can be performed automatically, *for example*, using the Weka Data Miner.

4.3 Query Support and Information Retrieval

Querying in multimedia databases can involve different multimedia data types, keywords, attributes, content, or even contextual information. Because of the different ways in which users think about multimedia data, multimedia query can simultaneously involve multiple indications, necessitating multiple or multidimensional indices. Queries are usually imprecise. Because of this and the difficulty of ensuring exact matches between multimedia data items, retrieval usually involves comparing data items for similarity or partial (rather than exact) matching. Thus, since queries might not yield exact matches, we need facilities for ranking the retrieved results according to how closely they match the given query. Similarly, we should have methods to prune results that do not seem to satisfy the query. Doing so reduces the potentially enormous computation needed for further matching.

With the ranking, the multimedia DBMS should also support browsing the various retrieved items. We might also want to retrieve similar items based on one or more of the already retrieved items.

With users unsure of the information required, a true multimedia DBMS also needs a facility to support incomplete information. More importantly, since the information extracted to index the multimedia data or from the user query might contain errors, query interpretation should provide for uncertainties in the information. This might require an iterative search mechanism and a relevance feedback mechanism along with techniques for query reformulation

4.4 Multimedia Databases Indexing

As in traditional databases, multimedia information can be retrieved using identifiers, attributes, keywords, and their conjunctions using conditional statements. Keywords are by far the predominant method used to index multimedia data. A human typically selects keywords from a set of specialized vocabulary. While simple and intuitive, this method usually creates problems when applied to multimedia data: it is basically manual and time consuming, and the resulting indices are highly subjective and limited depending on the vocabulary.

Another method, content-based access, refers either to; the actual contents of the multimedia database or to derived contextual information. Intensive research has focused on content-based indexing in recent years, with the goal of indexing the multimedia data using certain features derived directly from the data. Various features, *such as* color, shape, texture, spatial information, symbolic strings, and so on, have been used to index images.

Deriving such features requires automatic analysis of the multimedia data. The primary methods used for image and video data are image processing, image understanding, and video sequence analysis. With video data, the video sequence is first separated into its constituent scenes, and then representative abstractions (usually key frames) are selected to represent each scene. Further indexing on the video is based on the key frame, as in the case for images.

For audio data, content-based indexing could involve analysis of the audio signal or automatic speech recognition followed by keyword-based indexing. On the other hand, indexing can be based on other information depending on the type of audio data. For example, some developers have used rhythm signature, chord, and melody for content-based indexing of music data. Similarly, methods for content-based search and retrieval of audio data have been proposed based on the characteristics of audio data, as indicated by its perceptual and acoustic features.

Using content-based indexing implies the consideration of certain issues. First, the same multimedia data could mean different things to different people. Second, users typically have diverse information needs. Thus, it is evident that a single feature may not be sufficient to completely index a given multimedia data type. Therefore, it becomes difficult to identify the features that are most appropriate in any given environment.

Another problem has to do with efficiency; making the indexing fast and storing the indices efficiently for easy access, since multimedia data typically come in huge volumes. Because of the diverse content inherent in multimedia data, indexing has not been completely automated. *For example*, while the computer can easily analyze a picture containing works of art, it is almost impossible for the computer to automatically determine the meaning of the art object. Only a human can provide such information.

Figure 4.1 represents the main structure for the multimedia information retrieval illustrating the relationships and logi1al sequence between the various components of the multimedia information retrieval system.

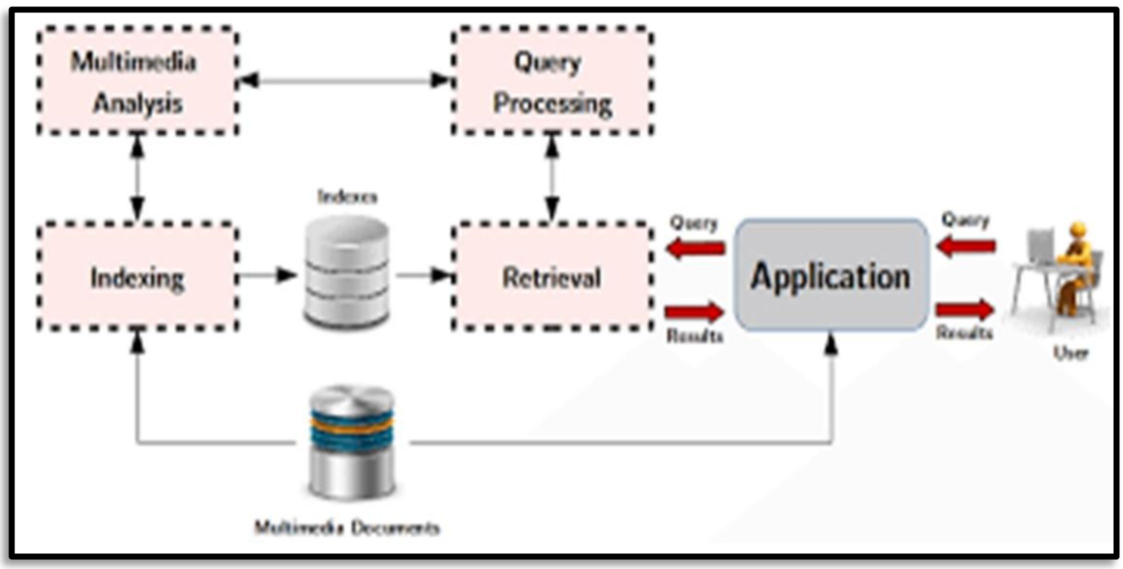


Figure 4.1: The Structure of the Multimedia Information Retrieval.

4.5 Multimedia Query Support, Retrieval, and Browsing

A Multimedia Information System (MMIS) is a repository for all types of electronically representable data. Conventional databases provide a large set of operations for retrieval of simple data types. The simplest way of extending this to multimedia objects is to store and retrieve on the basis of a few manually entered associated attributes or links. The true potential of multimedia databases is realized when a rich set of operations is provided to allow transparent manipulation of data objects of all media. This can best be achieved through content retrieval, based on the automatic interpretation of medium objects. Automatic content retrieval avoids the problems of inconsistency, subjectivity and the labor-intensiveness of manual entry.

User queries are often processed using only available indices. However, unlike in traditional databases, matches in multimedia queries are not exact matches. Often when comparing two multimedia data items; approximate or similarity matches result. Given that various items can resemble the same input data, a single query might yield many items in response.

Various research efforts have chosen to investigate issues on similarity matching involving multiple indices and ranking. Also being developed are appropriate ways of presenting the retrieved information, such as through a browsing interface. A user-directed browsing lets the user retrieve any information potentially related to the current results by selecting the data items for further consideration.

Among the issues involved in multimedia query support is the availability of a multimedia query language capable of supporting both the various media types encountered in a typical multimedia database and new requirements *such as* fuzzy query predicates. Such query models should also provide mechanisms for users to reformulate their queries, perhaps based on the already retrieved results as described below in figure 4.2.

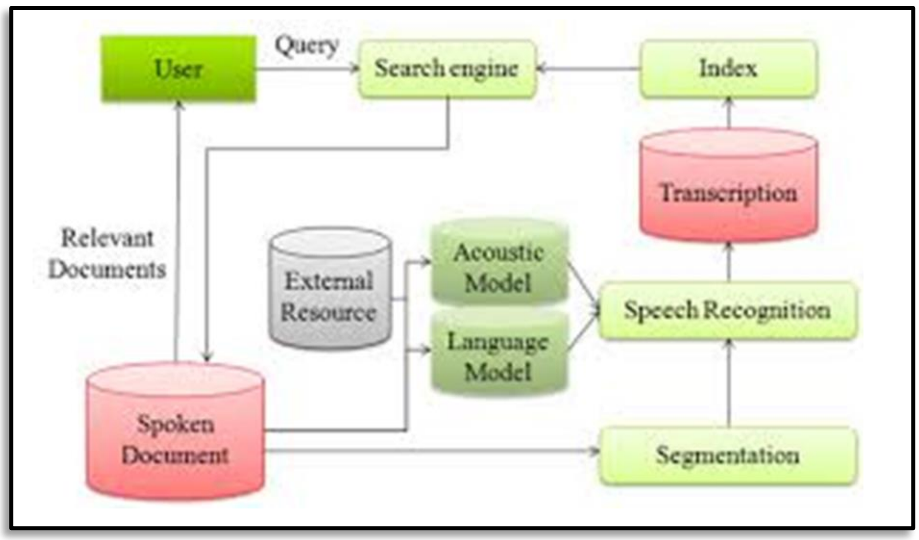


Figure 4.1: The Construction of Multimedia Query Support

Query-by-example is the primary method used to enter queries in multimedia databases, especially in those involving images. Here, the user makes a request using an existing example (for example, similar images). Thus, the interface used to enter the query into the system becomes an issue. Since different multimedia data types may require different query interfaces, the problems to consider include how to integrate the various interfaces in an integrated multimedia database system. Other problems to be resolved include querying spatial data and content-based video query, which could involve temporal and spatial information.

4.6 Distributed Multimedia Database Management

Distributed multimedia DBMS loosely refers to a collection of various (possibly) independent multimedia database management systems, located in disparate locations that can communicate and exchange multimedia data over a network. Multimedia systems are usually distributed in the sense that a single multimedia interaction often involves data obtained from distributed information repositories. This is typically the case in collaborative multimedia environments, where multiple users in possibly disparate physical locations manipulate and author the same multimedia document. Moreover, issues like storage problems and data generation may also force multimedia system designers to place multimedia data in different physical locations.

To support the information required in such distributed and collaborative environments, a distributed multimedia DBMS must address the general problems in distributed databases, such as distributed and parallel query processing, distributed transaction management, data location transparency, data security, and so forth. In addition, network issues such as limited bandwidth and network delays become important considerations, since they could have adverse effects on the QoS supported. Unlike in the traditional DBMS, data replication is often not encouraged in a distributed multimedia DBMS due to the huge data volumes. The client-server computing model, in which a server application services multiple client applications— with the clients and server residing in possibly different machines—has proven suitable for multimedia systems in general and distributed multimedia DBMSs in particular.

4.7 Challenges of Multimedia Database Retrieval

The quality of MMIR Systems depends heavily on the quality of the training data. Discriminative descriptions can be extracted from media sources in various forms. Machine learning provides categorization methods for all types of data. However, the classifier can only be as good as the given training data. On the other hand, it requires considerable effort to provide class labels for large databases. The future success of MMIR will depend on the provision of such data. The annual TRECVID competition is currently one of the most relevant sources of high-quality ground truth.

As a result of the recent explosion in the quantity of digital media, there is an urgent need for new and better techniques for accessing data. Indexing and retrieval are at the heart of multimedia system design—large amounts of multimedia data may not be useful if there are no effective tools for easy and fast access to the collected information. Once collected, the data must be organized efficiently, so that a query search via a search engine will yield a limited, yet useful, number of results. The retrieval process is designed to obtain limited information which satisfies a user at a particular time and within a particular domain application; however, this does not often work as efficiently as intended. A significant challenge, therefore, is to develop techniques that can "interpret" the multimedia content in large data collections to obtain all the information items relevant to the user query, while retrieving as few non-relevant ones as possible.

The analysis and retrieval of multimedia content in large-scale image and video databases faces more challenges than in small scale content-based multimedia analysis. Some of the unique challenges of large-scale multimedia analysis include:

- ***Automatic classification and retrieval, with minimum human labeling and intervention*.** According to a recent study, among web-based image and video consortia, only 5–10% of the data are labeled. The majority of multimedia data cannot be retrieved using current text-based search engines.
- ***Multimedia retrieval, including efficient database index, compact storage, and quick and accurate retrieval performance.*** Since large-scale databases consist of millions of images, the computational efficiency of both off-line and on-line retrieval processes is crucial.
- ***Integration with cross platform-based applications*.** With the emerging technologies of mobile devices and cloud computing, a lot of desktop-based multimedia applications need to be migrated to cloud and must find suitable positions in the mobile domain.

Multimedia database retrieval has attracted researchers from the fields of computer vision, machine learning, database technology, and multimedia for almost two decades. It still remains a popular research direction, especially when considering how to cope with the vast size and increasing growth of multimedia data. There are two major difficulties with large-scale image datasets:

- One is the vast amount of labor required in manual image annotation, and
- The other is how to understand different human perceptions towards the same image content.

Moreover, the question of how to efficiently index large-scale image archives for fast retrieval was also raised as a fundamental consideration in designing large-scale image retrieval systems.

4.8 System Support

Multimedia applications in general, and distributed multimedia database systems especially, raise new issues in all aspects of the computer system, from operating systems to networks to general hardware. Most generally available operating systems do not support real-time operations adequately. Rather, they provide hardware front-ends for transmitting and presenting multimedia data.

Some multimedia data, *such as* continuous media, may require real-time delivery and presentation, although the real-time requirements might not be as stringent as those encountered in hard real-time systems. Thus, the multimedia database system cannot fully provide its functionalities until support for real-time continuous media data becomes an integral part of the operating system. Efforts on various fronts have concentrated on this problem, including research on resource scheduling, operating system support for QoS, use of multilevel and user-level threads, and so on.

Other characteristics of multimedia, such as the huge data volumes, may mandate special constraints on the system in terms of memory management, CPU performance, throughput, and so forth. Related issues include general considerations on I/O hardware to support the various media types involved in multimedia databases.

Communication networks—needed to transport the data for distributed multimedia environments— must support bandwidth and delay guarantees as needed to meet the stringent QoS requirements for certain multimedia applications.

Review Questions

Q1. What is meant by Multimedia Information Retrieval (MMIR)? – State the three groups of the MMIR methodology.

Q2. Describe the feature extraction methods related to the multimedia information retrieval.

Q3. Illustrate the Merging and Filtering Methods in the multimedia information retrieval.

Q4. Explain the Categorization Methods related to the multimedia information retrieval – State what the list of applicable classifiers may include.

Q5. How Querying process can be performed in multimedia databases.

Q6. Explain the main methods for multimedia databases indexing in MMIS.

Q7. Represent using figure only the main structure for the multimedia information retrieval in MMIS.

Q8. Illustrate the concept of distributed multimedia DBMS.

Q9. Discuss the Challenges of multimedia database retrieval in the MMIS.

Q10. State some of the unique challenges of large-scale multimedia analysis.

Q11. Multimedia database retrieval has attracted researchers from the fields of ………….., ……………., ……………, ……………. . [*Complete*]

Q12. What are two major difficulties with large-scale image datasets in multimedia database retrieval?

Q13. Explain the main methods required for supporting the MMIS.

Chapter Five

A DIGITAL LIBRARY

Chapter Five

A DIGITAL LIBRARY

The transition from an analog to a digital environment can be considered as a cultural revolution since the physical aspect of objects is changing. Digitization represents much more than a simple technique. Due to all possible forms of usage and applications it can be seen as a cultural phenomenon. Other than technical possibilities that have been opened up by digitization, the general public has now also come into contact with some applications that have become increasingly important.

5.1 Digital Libraries Concepts and Terminology

A virtual library is a library where documents are virtual, i.e. without a stable support. There are several advantages to virtual libraries. First of all, they are dematerialized and their location therefore becomes insignificant. Digital libraries have the advantage of universal access. Digital documents can also be accessed by several users at a time. Thousands of people can visualize and download a document without hindering others doing the same.

This type of library is far from being homogenous. Its sources, structures and documents are highly diversified, they stem from internal (institutional) production, commercial production, online collections etc. Their documents are real multimedia documents, i.e. hybrids of different forms of media. These documents need to be organized, and standardized access to them must be provided.

A digital library is a real library since its collection is organized, selected and well presented. Its documents are processed and administrated and their access can be controlled. A digital library also responds to the need to develop collections of documents *such as* digital resources, articles, books, etc.

A **digital library** is a special library with a collection of digital objects that can include text, visual material, audio material, video material, stored as electronic media formats (as opposed to print, or other media), along with means for organizing, storing, and retrieving the files and media contained in the library collection. Digital libraries can vary greatly in size and scope, and can be maintained by individuals, organizations, or affiliated with established physical library buildings or institutions, or with academic institutions. The digital content may be stored locally, or accessed remotely via computer networks. An electronic library is a type of information retrieval system.

The term *digital libraries* were first popularized by the NSF/DARPA/NASA Digital Libraries Initiative in 1994. These draw heavily on Vannevar Bush's essay *As We May Think* (1945), which set out a vision not in terms of technology, but user experience. The term *virtual library* was initially used interchangeably with *digital library* but is now primarily used for libraries that are virtual in other senses (*such as* libraries which aggregate distributed content). In the early days of digital libraries, there was discussion of the similarities and differences among the terms *digital*, *virtual*, and *electronic*.

In the context of the DELOS, a Network of Excellence on Digital Libraries, and DL.org, a Coordination Action on *Digital Library Interoperability, Best Practices and Modelling Foundations*, Digital Library researchers and practitioners and software developer produced a **Digital Library Reference Model** which defines a digital library as: "A potentially virtual organization, that comprehensively collects, manages and preserves for the long depth of time rich digital content, and offers to its targeted user communities specialized functionality on that content, of defined quality and according to comprehensive codified policies".

A distinction is often made between content that was created in a digital format, known as born-digital, and information that has been converted from a physical medium, e.g. paper, through digitization. It should also be noted that not all electronic content is in digital data format. The term hybrid library is sometimes used for libraries that have both physical collections and electronic collections. For example, American Memory is a digital library within the Library of Congress.

Some important digital libraries also serve as long term archives, *such as* arXiv and the Internet Archive. Others, *such as* the Digital Public Library of America, seek to make digital information from various institutions widely accessible online.

Many academic libraries are actively involved in building institutional repositories of the institution's books, papers, theses, and other works which can be digitized or were 'born digital'. Many of these repositories are made available to the general public with few restrictions, in accordance with the goals of open access, in contrast to the publication of research in commercial journals, where the publishers often limit access rights. Institutional, truly free, and corporate repositories are sometimes referred to as digital libraries.

5.2 History of Digital Libraries

The concept of digital libraries emerged in 1892 from the early ideas of Paul Outlet in ways to cease the violent wars, eliminate national boundaries, and allow humanity to become balanced. He discussed in his book called "*Birth of the Information Age*" about how to interlink millions of documents, images, audio and video files together so people could search in one system. He called it the "Mundaneum." In present time, this idea is closely associated with the Internet. Vannevar Bush and J.C.R. Licklider are two more contributors that advanced this idea into newer technology.

Bush was seen as a researcher that assisted in making the bomb that was dropped on Hiroshima. After seeing the disaster, he wanted to create a machine that would show how technology can lead to understanding instead of destruction. This machine would include a desk with two screens, switches and buttons, and a keyboard. He named this the "Memex." This way individual would be able to access stored books and files at a rapid speed.

In 1956, Ford Foundation funded Licklider to analyze how libraries could be improved with technology. Almost a decade later, his book entitled "*Libraries of the Future*" included his vision. He wanted to create a system that would use computers and networks so human knowledge would be accessible for human needs and feedback would be automatic for machine purposes. This system contained three components, the corpus of knowledge, the question, and the answer.

Early projects centered on the creation of an electronic card catalogue known as Online Public Access Catalog (OPAC). By the 1980s, the success of these endeavors resulted in OPAC replacing the traditional card catalog in many academic, public and special libraries. This permitted libraries to undertake additional rewarding co-operative efforts to support resource sharing and expand access to library materials beyond an individual library.

An early example of a digital library is the Education Resources Information Center (ERIC) which was "born digital" in 1966.

In 1994, digital libraries became popular due to the $24.4 million that the U.S. federal funded among six universities for research. The universities included Carnegie Mellon University, University of California-Berkeley, University of Michigan, University of Illinois, University of California-Santa Barbara, and the Stanford University.

5.3 Digital Archives

Physical archives differ from physical libraries in several ways. Traditionally, archives are defined as:

- Containing primary sources of information (typically letters and papers directly produced by an individual or organization) rather than the secondary sources found in a library (books, periodicals, etc.).
- Having their contents organized in groups rather than individual items.
- Having unique contents.

The technology used to create digital libraries is even more revolutionary for archives since it breaks down the second and third of these general rules. In other words, "digital archives" or "online archives" will still generally contain primary sources, but they are likely to be described individually rather than (or in addition to) in groups or collections. Further, because they are digital, their contents are easily reproducible and may indeed have been reproduced from elsewhere. The Oxford Text Archive is generally considered to be the oldest digital archive of academic physical primary source materials.

Archives differ from libraries in the nature of the materials held. Libraries collect individual published books and serials, or bounded sets of individual items. The books and journals held by libraries are not unique, since multiple copies exist and any given copy will generally prove as satisfactory as any other copy. The material in archives and manuscript libraries are "the unique records of corporate bodies and the papers of individuals and families".

A fundamental characteristic of archives is that they have to keep the context in which their records have been created and the network of relationships between them in order to preserve their informative content and provide understandable and useful information over time. The fundamental characteristic of archives resides in their hierarchical organization expressing the context by means of the archival bond. Archival descriptions are the fundamental means to describe, understand, retrieve and access archival material. At the digital level, archival descriptions are usually encoded by means of the Encoded Archival Description XML format. The EAD is a standardized electronic representation of archival description which makes it possible to provide union access to detailed archival descriptions and resources in repositories distributed throughout the world.

Digital libraries benefit from the existence of sophisticated formal models, *such as* The 5S Framework: Streams, Structures, Spaces, Scenarios and Societies, which allow us to formally describe them and to prove their properties and features.

Given the importance of archives, a dedicated formal model, called NEsted SeTs for Object Hierarchies (NESTOR), built around their peculiar constituents, has been defined. NESTOR is based on the idea of expressing the hierarchical relationships between objects through the inclusion property between sets, in contrast to the binary relation between nodes exploited by the tree. NESTOR has been used to formally extend the 5S model to define a digital archive as a specific case of digital library able to take into consideration the peculiar features of archives.

5.4 Technical Issues Challenging Digital Libraries

No doubt that, new technologies do not replace the old ones, but they actually complete and integrate each other. In libraries the traditional and the new technologies amplify each other. Librarians need to pay attention and react to new techniques and methods that come up in their field of work. On the other hand, they do not have to forget about their traditional tasks as the documents they are in charge of, as well as their clients, belong both to the old and the new era. By learning how to use traditional methods and understanding the cultural aspects of a library, librarians will find it easier to use future technology without threatening the library’s essence. The design of a digital library must take into account the following basic problems:

- **Size of Data:** Digital Library data objects can be very large. Retrieving these large data objects in a global distributed environment with the limited bandwidth available leads to unacceptable response time in user interactions.
- **Number of Data Objects:** Not only is each data object large, there are billions of such objects. A NASA image database would contain millions of images. A video database

associated with a video conference would contain hundreds of thousands of video clips. The library of Congress has thousands and thousands of books and journals.

- **Number of Sites:** The number of locations of information repositories available is increasing every day. This can be observed by the explosive increase in World Wide Web servers in the past few years. A digital library database requires access to many more sites containing data than a traditional database where only specialized users access data. A site could be where a user is located or a database is stored.
- **Number of Users:** The Global Information Infrastructure visualizes every home to have a computer with easy access to the information highway. The number of new Internet users will increase with home computers.

The above issues all refer to the previously unprecedented scaling that has to be done to make global digital libraries possible. This problem is only going to get worse as the number of users gets closer to the population of the world. ***The other technical issues are:***

- **Heterogeneity**: There are a multitude of data types available in the information repositories. The complex information consists of data from a variety of media: text, video, audio, images, slides, maps, photographs, numerical data, software, etc. The nature of the diverse creation of information sites all over the world results in the presence of heterogeneous repositories. These can range from special-purpose high performance servers to desktops and from highly structured data stores to unstructured files. The web has succeeded in providing a reasonable seamless interface. HTTP and HTML together mask the underlying differences in computing power and software structure and provide the user a coherent, consistent view of the underlying information sources.
- **Integration**: Technologies developed in databases, communications, multimedia, distributed information systems, human-computer interaction, electronic commerce, and security have to be integrated to adopt this new paradigm of information dissemination. The technical aspects of integration will involve identifying and specifying interactions between the different fields.
- **The legal and economic issues** have to be resolved without hampering the functionalities provided at the technical level.

5.5 Digital library Applications

The applications of digital libraries are equally diverse according to the diversity of digital library data objects. They range from technical to home-use applications and from critical to entertainment based applications:

- **Education**
    - Elementary School: geographical images, historical collections, science teaching etc.
    - College Students: reference material, technical talks, collaboration with other students etc.
- **Medicine**:
    - Expert medical service in remote rural areas.
    - Access to case studies by prominent surgeons and physicians.

    - Aid to consulting with distant experts using audio-visual aids.
- **Publishing**:
    - Supply newspapers and magazines to inaccessible areas.
    - Ability to extract only relevant content from newspapers and magazines.
    - A new means for generating revenue: New medium for advertisement.
- **Law**:
    - Access to old legal cases.
    - Aid to consultations with legal experts.
- **Consumerism**:
    - Shop from home: select product, order and view from home.
    - Can shop all over the world.
- **Online consumer guides are very good advertisement.**
- **Research**: access to resources (literature, technology) all over the world, collaboration with fellow researchers.
- **Public access to NASA data**: Earth Observing System in 2000 will collect over one terabyte of data a day and should be available to the public at a reasonable cost.

5.6 Digitization and Software Implementation

In the past few years, procedures for digitizing books at high speed and comparatively low cost have improved considerably with the result that it is now possible to digitize millions of books per year. Google book-scanning project is also working with libraries to offer digitize books pushing forward on the digitize book realm.

Institutional repository software is designed for archiving, organizing, and searching a library's content. Popular open-source solutions include DSpace, EPrints, Digital Commons, and Fedora Commons-based systems Islandora and Hydra. The design and implementation in digital libraries are constructed so computer systems and software can make use of the information when it is exchanged. These are referred to as semantic digital libraries. Semantic libraries are also used to socialize with different communities from a mass of social networks.

DjDL is a type of semantic digital library. Keywords-based and semantic search are the two main types of searches. A tool is provided in the semantic search that creates a group for augmentation and refinement for keywords-based search. Conceptual knowledge used in **DjDL** is centered around two forms; the subject ontology and the set of concept search patterns based on the ontology. The three type of ontologies that are associated to this search are bibliographic ontologies, community-aware ontologies, and subject ontologies.

There are a number of software packages for use in general digital libraries, for notable ones see Digital library software. Institutional repository software, which focuses primarily on ingest, preservation and access of locally produced documents, particularly locally produced academic outputs, can be found in Institutional repository software. This software may be proprietary, as is the case with the Library of Congress which uses Digiboard and CTS to manage digital content.

5.7 Searching of Digital Libraries

Most digital libraries provide a search interface which allows resources to be found. These resources are typically deep web (or invisible web) resources since they frequently cannot be located by search engine crawlers. Some digital libraries create special pages or sitemaps to allow search engines to find all their resources. Digital libraries frequently use the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) to expose their metadata to other digital libraries, and search engines like Google Scholar, Yahoo! and Sciruscan also use OAI-PMH to find these deep web resources.

There are two general strategies for searching a *federation* of digital libraries: distributed searching and searching previously harvested metadata.

- **Distributed Searching** typically involves a client sending multiple search requests in parallel to a number of servers in the federation. The results are gathered, duplicates are eliminated or clustered, and the remaining items are sorted and presented back to the client. Protocols like Z39.50 are frequently used in distributed searching. A benefit to this approach is that the resource-intensive tasks of indexing and storage are left to the respective servers in the federation. A drawback to this approach is that the search mechanism is limited by the different indexing and ranking capabilities of each database; therefore, making it difficult to assemble a combined result consisting of the most relevant found items.
- **Searching over previously harvested metadata** involves searching a locally stored index of information that has previously been collected from the libraries in the federation. When a search is performed, the search mechanism does not need to make connections with the digital libraries it is searching - it already has a local representation of the information. This approach requires the creation of an indexing and harvesting mechanism which operates regularly, connecting to all the digital libraries and querying the whole collection in order to discover new and updated resources. OAI-PMH is frequently used by digital libraries for allowing metadata to be harvested. A benefit to this approach is that the search mechanism has full control over indexing and ranking algorithms, possibly allowing more consistent results. A drawback is that harvesting and indexing systems are more resource-intensive and therefore expensive.

5.8 Digital Preservation and Metadata Creation

Digital preservation aims to ensure that digital media and information systems are still interpretable into the indefinite future. Each necessary component of this must be migrated, preserved or emulated. Typically lower levels of systems (floppy disks for example) are emulated, bit-streams (the actual files stored in the disks) are preserved and operating systems are emulated as a virtual machine. Only where the meaning and content of digital media and information systems are well understood is migration possible, as is the case for office documents. However, at least one organization, the Wider Net Project, has created an offline digital library, the eGranary, by reproducing materials on a 6 TB hard drive. Instead of a bit-stream environment, the digital library contains a built-in proxy server and search engine so the digital materials can be accessed using an Internet browser. Also, the materials are not preserved for the future. The eGranary is intended for use in places or situations where Internet connectivity is very slow, non-existent, unreliable, unsuitable or too expensive.

In traditional libraries, the ability to find works of interest is directly related to how well they were cataloged. While cataloging electronic works digitized from a library's existing holding may be as simple as copying or moving a record from the print to the electronic form, complex and born-digital works require substantially more effort. To handle the growing volume of electronic publications, new tools and technologies have to be designed to allow effective automated semantic classification and searching. While full text search can be used for some items, there are many common catalog searches which cannot be performed using full text, including:

- finding texts which are translations of other texts
- differentiating between editions/volumes of a text/periodical
- inconsistent descriptors (especially subject headings)
- missing, deficient or poor-quality taxonomy practices
- linking texts published under pseudonyms to the real authors (Samuel Clemens and Mark Twain, for example)
- differentiating non-fiction from parody (*The Onion* from *The New York Times*)

5.9 Copyright and licensing

Digital libraries are disadvantaged by copyright law because, unlike with traditional printed works, the laws of digital copyright are still being formed. The republication of material on the web by libraries may require permission from rights holders, and there is a conflict of interest between libraries and the publishers who may wish to create online versions of their acquired content for commercial purposes. In 2010, it was estimated that twenty-three percent of books in existence were created before 1923 and thus out of copyright. Of those printed after this date, only five percent were still in print as of 2010. Thus, approximately seventy-two percent of books were not available to the public.

There is a dilution of responsibility that occurs as a result of the distributed nature of digital resources. Complex intellectual property matters may become involved since digital material is not always owned by a library. The content is, in many cases, public domain or self-generated content only. Some digital libraries, such as Project Gutenberg, work to digitize out-of-copyright works and make them freely available to the public. An estimate of the number of distinct books still existent in library catalogues from 2000 BC to 1960, has been made.

The Fair Use Provisions (17 USC § 107) under the Copyright Act of 1976 provide specific guidelines under which circumstances libraries are allowed to copy digital resources. Four factors that constitute fair use are "Purpose of the use, Nature of the work, Amount or substantiality used and Market impact."

Some digital libraries acquire a license to lend their resources. This may involve the restriction of lending out only one copy at a time for each license, and applying a system of digital rights management for this purpose.

The Digital Millennium Copyright Act of 1998 was an act created in the United States to attempt to deal with the introduction of digital works. This Act incorporates two treaties from the year 1996. It criminalizes the attempt to circumvent measures which limit access to copyrighted materials. It also criminalizes the act of attempting to circumvent access control. This act provides an exemption for nonprofit libraries and archives which allows up to three copies to be made, one of which may be digital. This may not be made public or distributed on the web, however. Further, it allows libraries and archives to copy a work if its format becomes obsolete.

Copyright issues persist. As such, proposals have been put forward suggesting that digital libraries be exempt from copyright law. Although this would be very beneficial to the public, it may have a negative economic effect and authors may be less motivated to create new works.

Another issue that complicates matters is the desire of some publishing houses to restrict the use of digit materials such as e-books purchased by libraries. Whereas with printed books, the library owns the book until it can no longer be circulated, publishers want to limit the number of times an e-book can be checked out before the library would need to repurchase that book. "[HarperCollins] began licensing use of each e-book copy for a maximum of 26 loans. This affects only the most popular titles and has no practical effect on others. After the limit is reached, the library can repurchase access rights at a lower cost than the original price." While from a publishing perspective, this sounds like a good balance of library lending and protecting themselves from a feared decrease in book sales, libraries are not set up to monitor their collections as such. They acknowledge the increased demand of digital materials available to patrons and the desire of a digital library to become expanded to include best sellers, but publisher licensing may hinder the process...

5.10 Advantages of Digital Libraries

The advantages of digital libraries as a means of easily and rapidly accessing books, archives and images of various types are now widely recognized by commercial interests and public bodies alike.

Traditional libraries are limited by storage space; digital libraries have the potential to store much more information, simply because digital information requires very little physical space to contain it. As such, the cost of maintaining a digital library can be much lower than that of a traditional library. A physical library must spend large sums of money paying for staff, book maintenance, rent, and additional books. Digital libraries may reduce or, in some instances, do away with these fees. Both types of library require cataloging input to allow users to locate and retrieve material.

Digital libraries may be more willing to adopt innovations in technology providing users with improvements in electronic and audio book technology as well as presenting new forms of communication *such as* wikis and blogs; conventional libraries may consider that providing online access to their OP AC catalog is sufficient. An important advantage to digital conversion is increased accessibility to users. They also increase availability to individuals who may not be traditional patrons of a library, due to geographic location or organizational affiliation.

- **No physical Boundary**. The user of a digital library need not to go to the library physically; people from all over the world can gain access to the same information, if an Internet connection is available.
- **Round the clock availability** A major advantage of digital libraries is that people can gain access 24/7 to the information.
- **Multiple Accesses**. The same resources can be used simultaneously by several institutions and patrons. This may not be the case for copyrighted material: a library may have a license for "lending out" only one copy at a time; this is achieved with a system of digital rights management where a resource can become inaccessible after expiration of the lending period or after the lender chooses to make it inaccessible (equivalent to returning the resource).
- **Information Retrieval**. The user can use any search term (word, phrase, title, name, and subject) to search the entire collection. Digital libraries can provide very user-friendly interfaces, giving click able access to its resources.
- **Preservation and Conservation**. Digitization is not a long-term preservation solution for physical collections, but does succeed in providing access copies for materials that would otherwise fall to degradation from repeated use. Digitized collections and born-digital objects pose many preservation and conservation concerns that analog materials do not.
- **Space**. Whereas traditional libraries are limited by storage space, digital libraries have the potential to store much more information; simply because digital information requires very little physical space to contain them and media storage technologies are more affordable than ever before.
- **Added Value**. Certain characteristics of objects, primarily the quality of images, may be improved. Digitization can enhance legibility and remove visible flaws such as stains and discoloration.
- **Easily Accessible.**

5.11 Disadvantages of Digital Libraries

Due to the technological and digital revolution, the role of librarians and information officers has undergone important changes. The digital environment requires a higher level of technical skill not only to carry out editorial tasks or those linked to the organization of a library, but also to make the right strategic choices for the library as an institution. Therefore, digital libraries, or at least their digital collections, unfortunately also have brought their own problems and challenges in areas such as:

- User authentication for access to collections
- Copyright
- Digital preservation
- Equity of access
- Interface design
- Interoperability between systems and software
- Information organization
- Inefficient or nonexistent taxonomy practices (especially with historical material)
- Training and development
- Quality of Metadata
- Exorbitant cost of building/maintaining the terabytes of storage, servers, and redundancies necessary for a functional digital collection.

There are many large scale digitization projects that perpetuate these problems.

5.12 The Future of Digital Libraries

Large scale digitization projects are underway at Google, the Million Book Project, and Internet Archive. With continued improvements in book handling and presentation technologies *such as* optical character recognition and development of alternative depositories and business models, digital libraries are rapidly growing in popularity. Just as libraries have ventured into audio and video collections, so have digital libraries *such as* the Internet Archive. **Google Books** project recently received a court victory on proceeding with their book-scanning project that was halted by the Authors' guild. This helped open the road for libraries to work with Google to better reach patrons who are accustomed to computerized information.

According to Larry Lannom, Director of Information Management Technology at the nonprofit Corporation for National Research Initiatives (CNRI), "all the problems associated with digital libraries are wrapped up in archiving". He goes on to state, "If in 100 years people can still read your article, we'll have solved the problem." Daniel Akst, author of The Webster Chronicle, proposes that "the future of libraries — and of information — is digital".

Peter Lyman and Hal Variant, information scientists at the University of California, Berkeley, estimate that "the world's total yearly production of print, film, optical, and magnetic content would require roughly 1.5 billion gigabytes of storage." Therefore, they believe that "soon it will be technologically possible for an average person to access virtually all recorded information".

Review Questions

Q1. Illustrate in details what is meant by the concept of digital library.

Q2. Explain how physical archives differ from physical libraries in several ways.

Q3. Digital libraries benefit from the existence of sophisticated formal models, *such as* the 5S Framework – Describe how.

Q4. What are the main problems must be taken into account for the design of a digital library?

Q5. Discuss the technical issues should be considered when creating digital library.

Q6. Illustrate in details some applications of digital libraries.

Q7. Explain digitization process and software implementation in digital libraries – Give examples.

Q8. There are two general strategies for searching a *federation* of digital libraries … Discuss in details these two searching strategies.

Q9. Give examples for the common catalog searches which cannot be performed using full text.

Q10. How you can describe the concept of copyright and licensing in Digital libraries.

Q11. Prove in details the main advantages of digital libraries.

Q12. Demonstrate in details the main disadvantages of digital libraries.

Q13. According to your understanding… Give a comparative study for the main advantages and disadvantages of digital libraries.

Q14. Give abstract ideas about the future of digital libraries.

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