# ON-LINE BROADCAST ARCHIVES FOR INTERACTIVE VIDEO

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## Abstract

**Delivery of user specified interactive multimedia digital services is drawing world attention. With availability of greater number of channels as a result of video compression and geographical barrier receding, content providers are hard pressed to meet the programme requirements. Broadcast archives are valuable multimedia resource centres, stocking audio and video materials of interest to a vast population across the globe. There is a great potential of using these archives for on-line interactive access of the material. The present paper describes the system architecture and implementation issues of an On-Line Broadcast Archives Management system ( OLBAMS ) which entails various functions of storage and dissemination, taking advantage of emerging digital technology viz. video servers, OODBMS, CORBA, MPI video, use of jawa applets for set-tops, webTV, or computers.**

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# I. INTRODUCTION

The progress of digital technologies in production, storage and transmission of audio and video coupled with the possibility of delivery of the multimedia data by a variety of transmission medium including broadband networks, satellite and Internet, is rapidly changing the established concepts of broadcasting. The emergence and adoption of MPEG-2 [1] and other low bit rate coding like fractal [2] /wavelet [3] have brought the digital multimedia broadcasting into the realm of reality. Digital video /audio provide better quality, interactivity and greater channel efficiency. Multiple Perspective Interactive Video (MPI-Video) [4,5] provides the infrastructure for the processing and automatic analysis of multiple streams of video data to construct a ``virtual world" and view the video from user defined perspectives. With the DTH (Direct-To-Home) and Internet broadcasting [6], the geographical barriers are receding. However, greater number of digital channels require more number of programmes and content providers are hard pressed to meet the ever increasing programme requirements.

Broadcast archive hold valuable collection of music, film, talks, sound effects, video clips, still picture etc. The archival material is in video or audio form

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1. MPEG Committee's International Standard, "Generic Coding of Moving Picture and Associated Audio", ISO-IEC Recommendation No. 13818, 9th Nov. 1994.
2. Z. Barahav et. Al., *Fractal Image Compression: Theory and Application*, Springer-Verlag, New York, 1995, pp. 91-117.
3. J. Katto et. al., "A Wavelet Codec with Overlapped Motion Compensation for a Very Low Bit Rate Environment", IEEE Transactions on Circuits and Systems for Video Technology, Vol. 4, No. 3, pp. 328-338, 1994.
4. S. Moezzi, et. al., "Immersive Video" Technical Report VCL-95-104, Visual Computing Laboratory, University of California, San Diego, Mar. 1995.
5. A. Katkere, et al., "Towards Video- Based Immersive Environments", Visual Computing Laboratory, 9500 Gilman Drive, Mail Code 0407, La Jolla, CA 92093-0407, USA.
6. H. O. Srivastava, " Broadcasting Through Cyberspace", IEEE Transactions on Consumer Electronics, Vol. 42, No. 4, pp. 907-913, 1997.

generally stored in analog format on disks/tapes apart from paper scripts, albums etc. There is a growing need for systematic access to recorded material by making them available rapidly, conveniently, economically and with precision to meet the ever increasing programme requirements.

The trend towards digital broadcasting, lossless multi-copy production with the adoption of digital format, a scale of economy saving in storage space with compression techniques, availability of inexpensive video servers[7], OD (Optical Disks), CD (Compact Disks) etc. as storage devices, use of Object Oriented Database (OODB)[ 8], CORBA (COmmon Request Broker Architecture) [9] and JAWA [10] as information storage /retrieval technologies, have made the management of broadcast archives a very challenging and rewarding job. It is in this emerging scenario that the broadcast archives management needs a new methodology. A sound information system for the broadcast archive will play an important role in providing new forms of customer service, new distribution channels, rearranging organisation boundaries[11], redesigning business processes[12], enabling companies to capture global economies of scale and

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7. M. S. Chen, et al., "Support for Fully Interactive Playout in a Disk-Array-Based Video Server", Proc. ACM Multimedia 94, ACM Press, New York, pp. 391-398, 1994.
8. T. Korsson et al., "Understanding Object Oriented: A Unifying Paradigm", Communications of the ACM, Vol. 33, No. 9, pp. 40-64, 1990.
9. "The Common Object Request Broker: Architecture and Specification", Object Management Group, Revision 1.2, Dec. 1993".
10. J. Gosling and H. Mcgilton, "The Java(tm) Language Environment: A White Paper", at http://java.sun.com/whitePaper/java-whitepaper-1.html .
11. J.I. Cash Jr. and B.R Konsynski, "IS Redraws Competitive Boundaries", Harward Business Review, pp. 134-142, March-April 1985.
12. J.I. Cash Jr., et. al., "Corporate Information Systems Management: The Issues Facing Senior Executives", Irwin Homewood, Illinois, 1988.

provide services globally[13,14,15, 16,17].

This paper describes an On-Line Broadcast Archives Management System (OLBAMS) for delivery of a large variety of audio and video material from digital multimedia archive. This provides a system for delivering interactive video. OLBAMS has four main functions viz., Archives Management (AM), Information System Management(ISM), Transport Management(TM) and Finance Management (FM). The AM is responsible for converting the existing media into digital format. ISM is responsible for putting it on-line and providing all facilities for interactive access. TM is responsible for network operations for the delivery of the media and meta-data. The FM is responsible for accounting functions. These functions are performed with the help of various equipment or sub-systems. The functions of the OLBAMS are depicted in Fig. 1.

## II. METHODOLOGY

In recent years object-oriented approach has received attention from the computer and information system industries[18]. Using the object-oriented approach, the system is modelled by identifying a set of objects in conjunction with the attributes and the methods ( i.e. internal operations and messages) that manipulate the object data or request services from other objects. There are various task-analysis

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13. E.K. Clemons, "Evaluation of Strategic Investment in Information Technology", Communications of the ACM, Vol.34, No.1, pp. 23-36, 1991.
14. T.H. Davenport and J.E. Short, "The New Industrial Engineering: Information Technology and Business Process Redesign", Sloan Management Review, Vol.31, No.4, pp. 11-27, Summer 1990.
15. V. Gurbaxani and E. Whang, "The Information Systems on Organizations and Markets", Communications of the ACM, Vol.34, No.1, pp. 59-73, 1991.
16. B. Ives and S. L. Jarvenpaa, "Applications of Global Information Technology: Key Issues for Management", MIS Quarterly, Vol.15, No.1, pp. 33-49, 1991.
17. M. E. Porter and V. E. Miller, "How Information Gives You Competitive Advantage", Horward Business Review, pp. 149-160, July-Aug., 1985.
18. J. Ang. "A Classification of Advanced Office Systems to Aid in Their Development" Information & Management, Vol. 23, No.3, pp. 115-122, 1992.

methods such as Task System Design[19], GOMS[20] and Task-Analysis for Knowledge Description[21] for object oriented modeling. GOMS is a human cognitive model which encompasses four sets of components: *goals, operators, methods* for achieving the goals and *selection rules*. The term *task solver* has been used for method[22] and the same shall be used in this paper to analyse the task and development of a model.

## III. SYSTEM ARCHITECTURE

The On-Line Broadcast Archive Management System has four *task solvers* which are represented as objects with *goals* as attributes.

### 1. Description of task solvers

The administration of Broadcast Archives Management is realised by the help of four *task solvers* viz. AM, ISM, TM and FM who have pre-defined goals.

### 2. The goals of the *task solvers*

The analysis of BAMS results in defining the clear *goals* of these *task solvers* in administering services such as encoding, data updation, retrieval and display, video/audio-on-demand, delivery of programmes on-line or off line, access control, realisation of payment for the services provided etc.

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19. R. W. Bailey, *Human Performance Engineering: A Guide to System Designers*, Prentice Hall, NJ, 1982.
20. S. K. Card, et. Al., *The Psychology of Human Computer Interaction*, Lawrence Erlbaum Associates, Hillsdale, NJ, 1983.
21. P. Johnson and S. Cook, *People and Computers: Designing the Interface*, Cambridge University Press, UK, 1985, pp. 46-62.
22. S. Wang, "Object Oriented Task Analysis", Information & Management, Vol. 29, No.6, pp. 331-341, 1995.

**i) The goal of Archives Management (AM)** ***task solver***

- Creating media-data by converting the existing analogue material into digital format (encoding and compression).
- Storing it on media-servers and other Direct Access Storage Device (DASD) such as Optical Disk, (OD), Compact Disk (CD). The media-servers are of different types, such as image server, voice server, text and graphics server, video server, etc.
- Creating Metadata[23] (Minimum Data List) in respect of each recording viz. Title, Singer, Composer, Theme, Category etc. as per a format. Graphics for photos /album etc. is also stored in compressed form.

**ii) The goal of Information System Management (ISM)** ***task solver***

- To use video parsing technique where possible.
- To provide an Hyperlink / Expert System (ES)/ visual category screen (with thumbnail images) based information Retrieval System for multimedia data viz. text, graphic, stills, video, audio etc.
- To provide Multiple Server-based distributed database for multimedia information as well as on-line digital video/audio for broadcast as well delivery using other means.
- To provide facility for access control, security, charging system for uses /payment of royalty, copyrights etc.
- To provide interface to the set-top or webTV or computer.

**iii) The goal of Transport Management (TM)** ***task solver***

- To provide system for delivery which could be a mix of Asynchronous

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23. R. Jain and A. Hampapur, "Metadata in Video Databases", In SIGMOD record: Special Issue On Metadata For Digital Media, ACM: SIGMOD, Dec. 1994.

Transport Mode (ATM), Synchronous Digital Hierarchy(SDH), Integrated Services Digital Broadcasting (ISDB), B-ISDN, ATM, Internet etc. for on-line information access / delivery of full video/audio.

**iv) The goal of Finance Management (FM) *task solver***

- To charge the users as per uses.
- To make payment for royalty.
- Other accounting functions.

The conceptual overview of the model has been depicted in Fig. 2.

## IV. SYSTEM IMPLEMENTATION

The operation part of each *task solver* object contains a set of processes called "operators" in the GOMS model. These operational processes are messages to task objects. The operation part of a *task solver* object usually also contains a set of selection rules that control the users decision path, while accomplishing the goal. Interface description specify the dialogue between user and computer. The system implementation of various modules are now discussed.

### 1. Material Transfer and storage considerations

The system uses object-oriented database (OODB) technology for holding media and meta data. CORBA defines common interfaces that allow system components written in different languages to communicate across a network. A Java applet adds CORBA functionality to any Java-enabled browser or a television interface. The hyper-media data is stored after compression using Joint Photographic

Experts Group (JPEG) [24] and the Moving Picture Expert Group (MPEG)[25] standards for still images, and full motion pictures. Signal processing allows enhancement of quality, where required. The suitable clippings are also stored in digital form viz. .AVI, .FLI etc.

Video disk servers for video-on-line which can serve MPEG-2 programs on high bandwidth networks are already available. 32 GB Redundant Array Inexpensive Disk Drives (RAIDs) provides approximately 3.5 hours of high-quality, randomly accessible video using 4:2:2 Studio Profile compression for non-linear playback. An illustrative object for this task solver is shown in Fig. 3 The system can be made completely computer controlled with functions such as load, rewind, play , record etc. being performed through computer instructions.

**2. Information system considerations**

The obvious candidates for the archives are Minimum Data List, audio/video (A/V) clips, audio/video programmes and stills stored in the digital form. For this type of multimedia data, it is important to be able to link various type of data efficiently so that users have access to large amount of related but unstructured information almost instantaneously, either by browsing or querying system. The system is called **Hypermedia Archives Information Retrieval System (H-AIRS)**. Hypermedia is a method of storing and retrieving discrete pieces of data. The data objects can be text, pictures, sound, video or a combination of these. A

24. G. K. Wallace, "The JPEG Still Picture Compression Standard", Communications of the ACM, Vol. 34, No. 4, pp. 30-44,1991.
25. D. Gall, "MPEG: A Video Compression Standard for Multimedia Applications", Communications of the ACM, Vol. 34, No. 4, pp. 46-58, 1991.

logical view of the multimedia data stored in the information-base is shown in Fig.4. The darken structures and text represent the video /audio data which is priced. It may be seen that while user can get an access to the excerpt free of cost and download it to his PC or Set-top, he may need authorisation to access the full video.

**i) An overview of H-AIRS**

A system architecture for H-AIRS is given in Fig. 5. The Information-base consists of schema object and multi-level object oriented data base. An interface manager is responsible for parsing the request and generating an internal representation which is handled by an object manager. The object manager has five major modules, the schema manager, the browser, the query manager, the transaction manager and the presentation manager[26]. The storage manager is responsible for storage and manipulation of the object oriented representation of multimedia material. The browser helps scan the data-base by user. The query manager processes the query by translating it into an appropriate language. The transaction manager is responsible for managing the transactions on objects. The presentation manager transforms the query in appropriate form.

**ii) Design Details of H-AIRS**

The nodes are conceptual data objects viz. voice, text, video, images or graphics. The interface manager's view of the data-base is a collection of nodes connected

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26. T. Bhavani, "Multilevel security for information retrieval system" Information & Management, Vol. 28 No.1, pp. 49-61,1995.

via various type of links. There are three types of nodes. Basic nodes store multimedia object for executing certain procedures. Organisational nodes are links or meta nodes. Inferential nodes are meant for intelligent information retrieval and are basically the rule nodes[27]. Links connect different nodes. The basic links are move -to/zoom/pan/view/ links. Organisational links or indexed/object links. Inferential links are associated with rule nodes.

**iii) Information Retrieving, browsing and updates**

Information retrieval is facilitated by the index nodes. When a user issues a request to retrieve a document, the interface manager scans the index text nodes using some key words specified in the query. From the index text nodes, appropriate index nodes are accessed. From the index nodes, concept nodes such as text, sound, video and mixed media nodes relevant to the query are accessed. When the data contained in a node has to be displayed, the *data and the corresponding data objects* are retrieved. Further mapping may be necessary so that the requests on the data objects are transformed into requests on files which contain them such as digital video, digital audio are pure text files. Eventually the corresponding files are retrieved and the contents are displayed/played. The operating system security feature for file access ensures that the file is not opened by unauthorised user. If a user wants to browse a network of nodes to obtain all the information about a specific item, a few key words result in opening a window from which he can traverse from one node to other by clicking on a link.

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27. K. Parsaye, et al, *Intelligent Databases*, John Wiley and Sons, New York, 1989.

The update operation is given to an update processor which parses the request and passes on to multimedia manager which is responsible for transforming the logical request into requests on file.

**iv) A Session**

Fig. 6 illustrates a session. Starting from the opening menu, the searcher moves to "Audio", "Music", "Classic", "Elvis Presley". During the entire session, a searcher moves through various classified objects which he is not able to access. These are shown with hashed nodes. The unauthorised user will not get any information if he clicks on these nodes. An authorised user is one who might have paid the subscription and has appropriate password. In case the subscription is not received, the system automatically cancels the allotted password.

## 3. Transport system considerations

The digital multimedia can be delivered through terrestrial, cable, satellite or Internet. The cable network (DVB-C) system has the same core as satellite system (DVB-S) except that the modulation technique is based on Quadrature Amplitude Modulation (QAM) rather than Quadrature Phase Shift Keying (QPSK) . No inner code forward error correction (FEC) is used. Channel coding for digital terrestrial broadcasting is OFDM[28]. The delivery of the information system can also be through a mix of ATM, SDH, B-ISDN, Internet etc. One prospect for Consumer Digital Information Distribution(CDID) is a digital bus to the home. This is equivalent to a Local Area Network (LAN) connected through routers or

28. Walker M. Gerald, "Year in review, year ahead: Digital all the way", World Broadcast News, pp. 26-28 , Jan. 1996.

gateways.

**4. Finance management issues**

Their can be various type of services viz. free-to-air broadcasting, subscription service and on-line information service. These are managed by using appropriate software.

## 5. SUMMARY

Archive is an important component of radio and TV broadcasting. With the advent of a number of broadcasting channels using satellite, terrestrial and cable network, the archival material has got a very high commercial value. Viewer/listeners as well as broadcasters are interested in accessing a variety of programmes either for personal use or redistribution. This has to be done interactively either by using information super-highway or through conventional channels. However, an on-line information system is a must to access the information about the material and also to view/listen/download the multimedia data. An automated system with a multimedia archival support may be a solution. A hyperlink based retrieval system has specific advantages. The present paper is an attempt to provide the direction for designing such a system. The bottom line is that the characteristics of mass IS are the voluntary use and a high degree of uncertainty exists about the users and their requirements. The user must gain substantial benefits to accept the system. The only way to success may be the step-wise implementation of services by observing and analysing the user behaviour. This evolutionary development and the diffusion process may take some years.

But the potential benefits for the broadcast organisations are high. To quote Bill Gates, "Whatever problems direct access to unlimited information may cause, the benefits it will bring, will more than compensate[29]."

[29] Bill Gates, *The Road Ahead*, Viking Penguin, USA, 1995

## Biography

**H. O. Srivastava** received the M.Sc. (Electronics) degree and Ph. D. in "Computer Database & Simulation". He joined Indian Broadcasting Service in 1972 and has been responsible for management and expansion of broadcast network in India. He got training in the Information Technology in UK, USA, Japan and Norway. He worked as Commonwealth Expert in 1991 and ITU Expert in 1992. He has published five dozen articles in national and international journals including IEEE and received six international awards. Currently he is Director, heading the IT department of All India Radio. His areas of interest are Information System, Digital storage and Multimedia Broadcasting.

**R. C. Jain** obtained his B.E. in Electronics and Communication and M.E. in Microwaves and Radar from the University of Roorkee, Roorkee in 1970 and 1978 respectively. He obtained his Ph. D. in Electrical Engineering from the University of Alberta, Canada in 1988 under the Commonwealth Fellowship Programme of the Government of India.

After completing his B.E. degree, he appeared in U.P.S.C. (Electronics Services) Examination, 1970 and was selected, for Class I gazetted post, to work in All India Radio (AIR). From July 1971-1979, he worked in different capacities at different centres of All India Radio which include High Power Transmitting Centre, Receiving Centre and Broadcasting Studios of AIR, Lucknow, AIR Centre, Mathura and Planning and Development Unit, AIR Headquarters, New Delhi. From July 1979 to August 1983, he worked in the Communications cell of

Indian Airlines Corporation (IA) on the planning of the communications network for IA's Real Time Reservation System apart from looking after a part of ground communications network. From September, 83 to October, 1988 he completed his Ph. D. in electrical engineering. In May 1989, he joined BITS, Pilani where, at present he is a Professor in Electrical and Electronics Engineering Group. His fields of interest are microwave engineering, analog electronics and image compression.

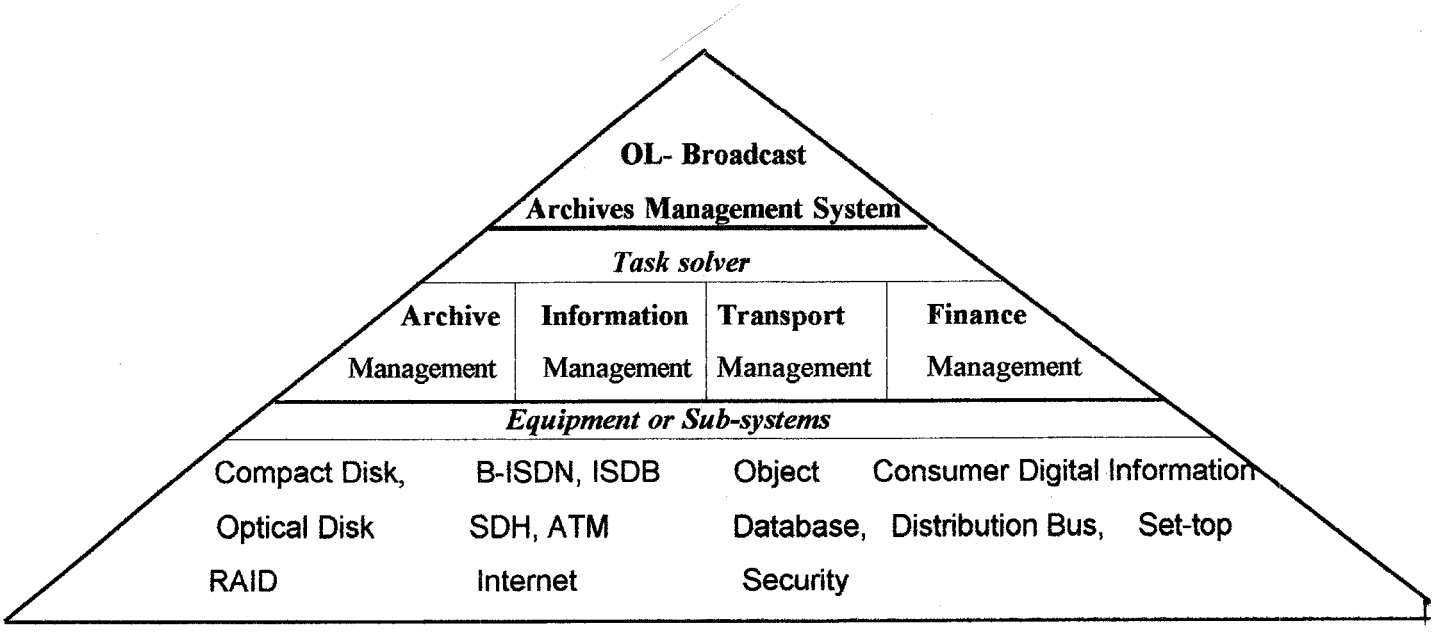


**Fig. 1 Functions of On-Line Broadcast Archives Management System**

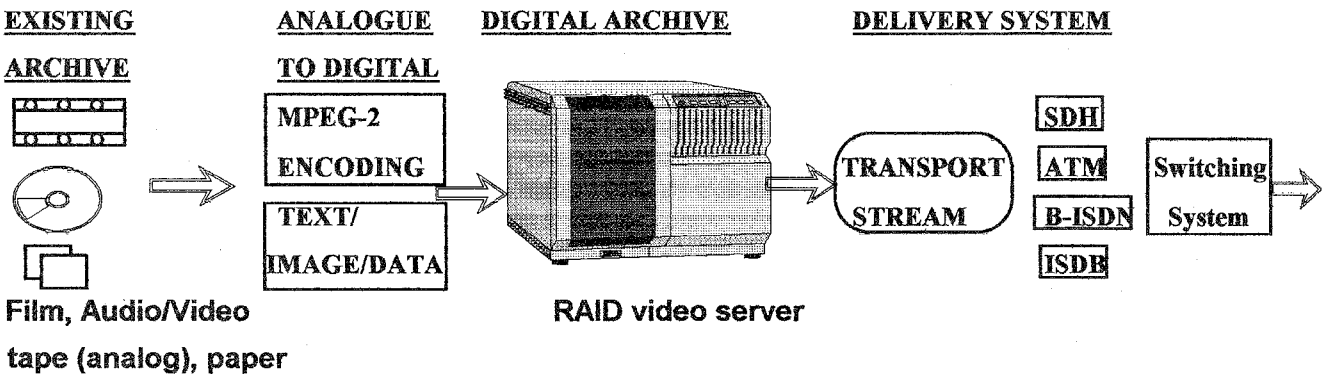


**Fig. 2 Conceptual view of On-LineBAMS model**

Author: H. O. Srivastava & R. C. Jain

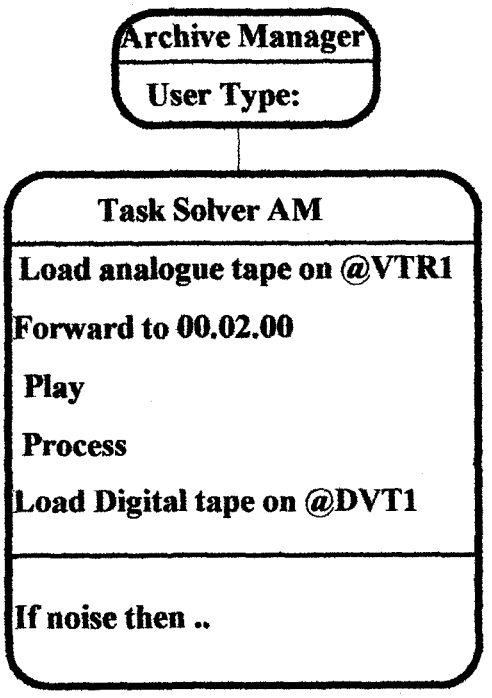


**Fig.3 Objects for Archive Manager**

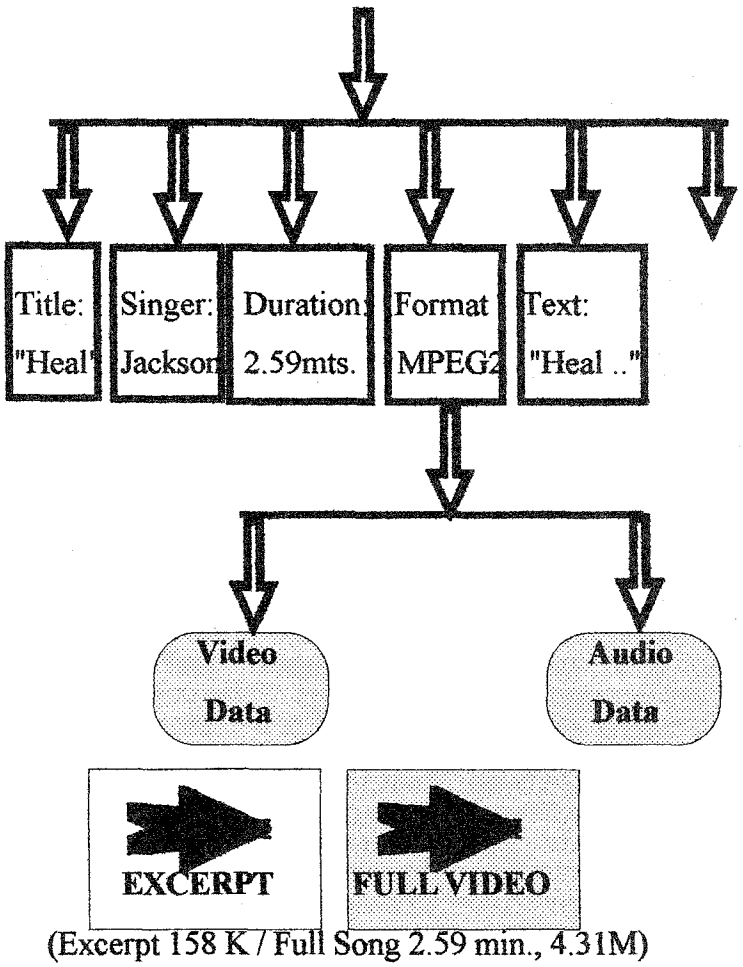


**Fig. 4 A Logical view of multimedia data**

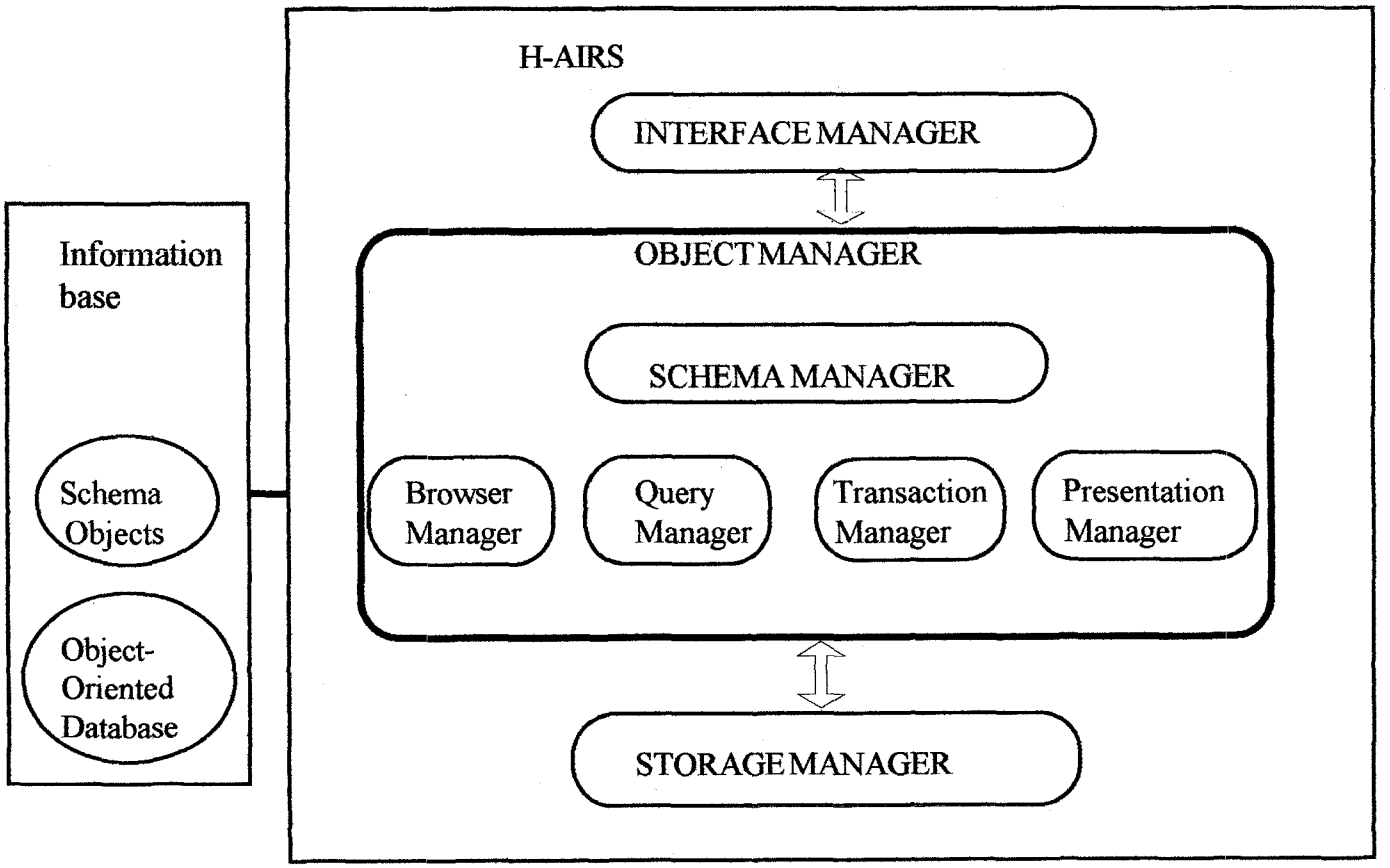


**Fig. 5 System Architecture of H-AIRS**

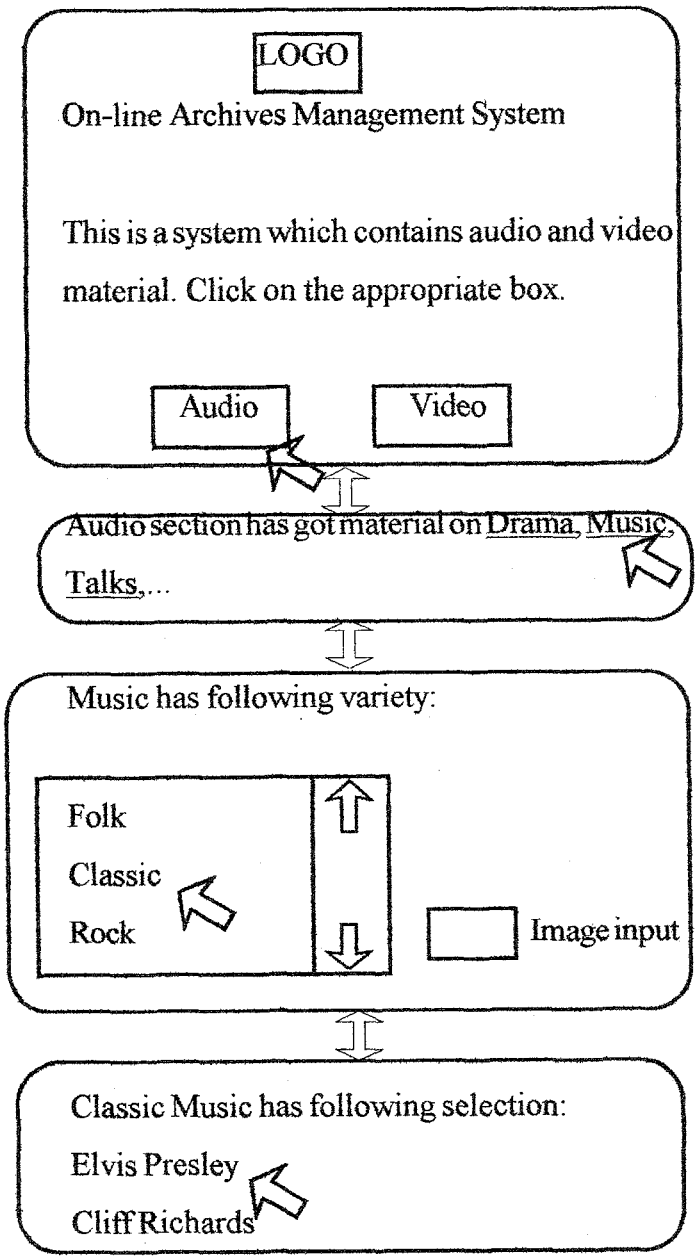


**Fig. 6 A session with the H-AIRS**