DEVELOPMENT OF INFORMATION SYSTEMS FOR BROADCAST ARCHIVES IN THE CONTEXT OF INFORMATION SUPERHIGHWAY

THESIS

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By

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Under the Supervision

of Prof. R. C. Jain

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CERTIFICATE

This is to certify that the thesis entitled DEVELOPMENT OF INFORMATION SYSTEMS FOR BROADCAST ARCHIVES IN THE CONTEXT OF INFORMATION SUPERHIGHWAY and submitted by Hari Om Srivastava ID. No. 95PHXF403 for award of Ph.D. Degree of the Institute, embodies original work done by him under my supervision.

Signature in full of the supervisor RCJain

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aspects of digital broadcast archives which encompasses automated, interactive, multi-channel delivery systems. The system architecture and IS model for broadcast archives uses Object Oriented Database (OODB), CORBA (COmmon Request Broker Architecture) and JAVA. The proposed On-Line Broadcast Archives Management System (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 and storing it on multiple servers. 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 advantages of the IS for broadcast archives, developed by us are enumerated below.

- The archive architecture includes all the aspects including creation and capture, storage, rights management, search and access, and distribution. This is a departure from the traditional system where distribution is not included in the archive architecture.
- The archives are in digital format and reside on video server, CD, OD, etc.
- Most of the holdings are on-line which can be accessed by a viewer.
- For those holdings which are not on-line, an excerpt is available for preview.
- The indices, picture segments and clippings are derived through key-frame extraction algorithm, where possible.
- The search is through hypermedia nodes, keywords or video browsers.

- Access control allows protection of intellectual property rights.
- The digital delivery is provided through Information Superhighway which allows access at any time by any person from any geographical location.
- A JAVA applet allows capture of viewer's preferences. This allows providing a specially designed programme package to individual viewer using server push technology. This really means possibility of a new channel to every individual.

The thesis is an effort to develop a model for truly interactive broadcasting through Information Super-highway. In this system, user can select the programme of his choice and listen / view it at his own choice of timings. User can also view specific scenes only. The server push technology allows user to receive programs based on his profile without really asking for the program.

Finally the scenario and the adoption of the system in India has been analyzed. It is concluded that the system is also most suited to the needs of All India Radio and TV India, the two broadcast organizations of the country.

Abstract

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. Research work has been initiated round the world, to integrate TV with the WWW technology. ISO has started work on MHEG-6 with this intention.

Archives are an integral part of the broadcasting. Archives contain variety of holdings viz. films, old recordings in the form of speeches, scenes, sound effects, video clips etc. All the programmes produced for broadcasts become part of the archive. The archival collection is used for new programme production and reference.

The traditional method of archives administration consists of storing the holdings in various analog formats, retrieving using cardex index system, duplicating and delivering to producers at several stations, using conventional postal systems. With the advent of computers, retrieval is based on DBMS (Data Based Management System) and 4G QL (Fourth Generation Query Language). While producing new programmes, the material is taken from the archives and cutting, splicing, joining, dubbing are used. The archives are not available to public except through the broadcast of the programmes. The delivery system is not a part of archive management.

In the present thesis, a novel Information system for interactive video /audio has been presented. The system has been designed to cater to the requirements of multiple

aspects of digital broadcast archives which encompasses automated, interactive, multi-channel delivery systems. The system architecture and IS model for broadcast archives uses Object Oriented Database (OODB), CORBA (COmmon Request Broker Architecture) and JAVA. The proposed On-Line Broadcast Archives Management System (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 and storing it on multiple servers. 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.

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Finally the scenario and the adoption of the system in India has been analyzed. It is concluded that the system is also most suited to the needs of All India Radio and TV India, the two broadcast organizations of the country.

List of Abbreviations

ADSL	Asymmetric Digital Subscriber Line
AIR	All India Radio
AOD	Audio-on-Demand
ATM	Asynchronous Transmission Mode
ATV	Advanced Television
B-ISDB	Broadband Integrated Services Digital Broadcasting
CATV	Community Access TV
CBR	Constant Bit Rate
CCIR	Comite Consultatif International de Radiodiffusion
CD	Compact Disk
CDID	Consumer Digital Information Distribution
CIF	Common Intermediate Format
DAB	Digital Audio Broadcasting
DAT	Digital Audio Tape
DARC	Data Radio Channel
DCC	Digital Compact Cassette
DDI	Doordarshan India
DBMS	Data Base Management System
DBS	Direct Broadcasting Satellite
DRW	Digital Radio Worldwide
DSR	Digital Satellite Radio
DSS	Direct Satellite Service
DTH	Direct-To-Home
DVB	Digital Video Broadcasting
EBU	European Broadcasting Union
ECM	Entitlement Checking Message
EDTV	Extra Definition TV
ENG	Electronic News Gathering
FEC	Forward Error Correction
GB	Giga Byte
HDTV	High Definition TV
HTML	Hyper Text Markup Language
HTTP	Hyper Text Transport Protocol
IS	Information System
ISDB	Integrated Services Digital Broadcasting
ISDN	Integrated Services Digital Network
ISO	International Standards Organization
ITU	International Telecommunication Union
JPEG	Joint Picture Expert Group
LAN	Local Area Network
LDTV	Low Definition TV
Mbps	Mega bits per second
MD	Mini Disc
MHEG	Multimedia Hyperlink Expert Group
MOD	Magneto-Optical Disc
MPEG	Motion Picture Expert Group

NAB	National Association of Broadcasters
OB	Outside Broadcasts
OODB	Object Oriented Data Base
PPV	Pay Per View
PTM	Packet Transfer Mode
QAM	Quadrature Amplitude Modulation
QCIF	Quarter CIF
QPSK	Quadrature Phase Shift Keying
RAS	Remote Access Service
RDS	Radio Data Service
SCSI	Small Computer System Interface
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical NETwork
SMPTE	Society of Motion Picture & Television Engineers
SQL	Sequential Query Language
STM	Synchronous Transfer Mode
TCP/IP	Transfer Control Protocol / Internet Protocol
TVI	Television India
URL	Uniform Resource Locator
VBR	Variable Bit Rate
VOD	Video-on-Demand
VRML	Virtual Reality Manipulation Language
WAN	Wide Area Network
WARC	World Administrative Radio Conference
WWW	World Wide Web

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Chapter 1

Broadcast Technology - Past, Present and Future : A Review

1.1 Background

We are living in an exciting age. The convergence of Information Technology, Telecommunications and Broadcasting have opened new vistas in the life of the common man. The "Information Society" shall have access to mass interactive communication services for life long learning, improved standards of living, better health care and socio-economic development. Anything and everything by way of information, education and entertainment will be available to anyone at any time. This will be possible through the emerging Information Superhighway.

Several elements will make broadcasting the most efficient lane on an Information Superhighway. The foremost is the digital broadcasting since in this mode the programmes - movies, sports, news etc. - can be multiplexed with other data viz. text, information, voice etc. and transmitted on a common distribution channel. Interactive broadcasting will be the key element of the future

"Information Society", where a listener / viewer shall have the control on the content and the time of listening /viewing. He shall also be able to select / compose the programme of his choice. This will require new methods of storage, access and retrieval. The programme archives require remodeling for this interactive mode of broadcasting.

In this thesis, we have analyzed the current and emerging broadcast technology, the requirements of programme production in the changing scenario, the changing needs of viewers / listeners and various options for broadcast archives to suit these requirements. We propound that the broadcast archive encompasses a variety of issues viz. storage, information management, retrieval, access control, delivery system etc. This is in contrast to the traditional definition of the archives which does not include delivery systems. Keeping in view that the delivery system is a part of archives, the information system model for broadcast archives presented in this thesis includes the Information Superhighway as a means to make the archives truly on-line and interactive. The thesis is organized in 6 Chapters. The broadcast history, new frontiers of the technological advancement and the objective of the research work have been described in the present Chapter. The status of the present broadcast archives, terminology used in the archives, the problems in the present system etc. are described in Chapter 2. Enabling technology for future Information System for broadcast Archives and certain broad parameters for storage, IS and delivery for future archives are described in Chapter 3. A System Architecture as well as a prototype design for an on-line interactive digital archive developed as a part of this research work is presented in Chapter 4. The most appropriate archive system for India is described in Chapter 5. Finally recommendations and the future trends has been presented in Chapter 6. An overview of past, present and future broadcast technology is given in the following sections.

1.2 Broadcasting Services

Of all the functions performed by radio communications, none is more familiar to the general public than broadcasting. Radio and television broadcasts provide entertainment, information and education to the masses. Over the last ten years, sound and television broadcasting are undergoing a revolutionary change from the established analog to digital technology. New services, including high definition television (HDTV), digital audio broadcasting (DAB), and new direct broadcast satellite services (DBS) will augment, and in some cases compete with, existing AM and FM radio, VHF and UHF television. Recently a new service of Cyberspace broadcasting has emerged which is being experimented by a number of broadcast organizations. The service provides flexibility of interactivity where listener /viewer can get the audio /video /animation etc. on-demand. They can control the type and timing of viewing /listening.

1.2.1 History of Broadcasting

Broadcasting traditionally encompassed Radio and Television broadcasting. Thereafter the concept of data broadcasting as a value-added service was introduced. In recent times broadcasters are considering Multi-Media broadcasting which consists of delivery of audio, video, data and text through a host of distribution system viz. terrestrial broadcast networks, satellite, ATM, SDH, fibre cable and internet. The history of broadcasting begins with the audio broadcast services through radio waves. The history of radio broadcasting is described below.

1.2.1.1 Radio

The era of radio broadcasting began in the year 1901 when G. Marconi achieved a dramatic success in transmitting radio signals across the Atlantic Ocean. By 1921, Medium Wave (531 to 1602 kHz extended to 1700 kHz in North America) radio broadcasting had become a reality. Shortwave (3 to 30 MHz) broadcasting was further demonstrated by Marconi in 1922. The powerful impact radio can have on the imagination of listeners was amply proved on the evening of Oct. 1938 when a direct broadcast of one hour play - "War of the World" - produced by Orson Wells from "Mercury Theatre" stunned the world [1]. The channel congestion lead to the use of VHF for broadcasting in 1950s. The introduction of frequency modulation on VHF frequencies promised and delivered much improved sound quality. The first stereo broadcasting on FM was introduced in 1962 for high quality audio. The availability of transistorised radios made the audience mobile. The era of digital audio broadcasting started in 1995 with the regular transmission of Digital Broadcasting in Europe. The chronology of the events for sound recording and the broadcast history are given in Table1.1.

Table -1 .1

Brief History of Sound Recording and Broadcasting Technology

1864	James Maxwell's electromagnetic wave theory becomes the basis for radio wave propagation.
1877	First description of recording sound onto a cylinder or disc described by Charles Cros in France and Thomas Alva Edison in the United States.
1878	Thomas Edison patents the recording of sound onto discs and cylinders.
1887	Heinrich Hertz transmits and receives radio waves over short distances.
1888	Emile Berliner shows first example of a working "phonograph" playback device.
1888	Basics of magnetic recording put forth by Oberlin Smith.
1889	Danish inventor Valdemar Poulsen patents the first magnetic recorder.
1895	Development of first wireless telegraph system by Guglielmo Marconi.
1905	First electron tube developed by Sir Ambrose Fleming.
1906	First wireless communication of human speech.
1919	KDKA in Pittsburgh, Pennsylvania is licensed as the first broadcast radio station.
1925	First electronic recordings made with the use of a microphone.
1931	First experimental stereo recordings made by Bell Telephone Laboratories.
1933	Theory of frequency modulation (FM) for radio broadcasts developed by Edwin Armstrong.
1948	Introduction of Long Play (LP) record by CBS.
1948	First transistor introduced.
1954	Introduction of stereo tapes to the public.
1962	First stereo FM radio broadcasts.
1975 - 1978	Early digital recording made.
1980	Sony introduces the "Walkman".
1983	First CD player made available through technology developed by Sony and Philips.
1995	Digital Broadcasting starts.

1.2.1.2 Television

The Television era started with the video broadcasting in 1936 by BBC. Colour was added to Television in 1950. NTSC, the US colour standard was adopted in 1953, with Europe following with the PAL standard in 1966. Television development continued with the introduction of UHF transmitters in 1952 to address the problem of spectrum limitation in VHF band. The launch of Sputnik in 1957 started the space race. With the formation of Intelsat by International Satellite organisation, a new era of global connectivity started. In 1975, the delivery of video programmes to cable head ends via satellite started. The demand of video entertainment by viewers not served by cable, gave rise to direct to home (DTH) delivery system beginning in Australia in 1984 followed by Europe and U.S. In order to provide improved quality of service, PALplus (Box 1.1) standards were evolved. However, broadcasters decided to drop the

Box 1.1

PALplus standard

The PALplus standard generates for each TV frame, 432 (216 per field) main active lines in 16:9 format, plus 144 (72 per field) helper active lines. The main active line contain basically a conventional PAL image information, while the helper lines contain additional information transmitted in a way that a conventional PAL TV receiver will interpret them as "black" lines. Those lines are transmitted for each field in the sequence: i) a group of 36 consecutive helper lines, ii) 216 main lines; iii) the remaining 36 helper lines. When receiving such a signal, a conventional 4:3 PAL TV receiver will display the image in 16:9 format in the center of the screen (letterbox format, already widely used for broadcasting feature films). A Palplus TV set generates a full screen image by appropriately combining main lines with the helper lines.

introduction of the analog widescreen PALplus format in favour of digital system [2]. In 1993, Europe began the project of digital television in the terrestrial 8/7 MHz channel. Digital satellite service was introduced in 1995. A brief history of video and television technology is given in Table-1.2

Table- 1.2

Brief History of Video and Television Technology

1897	Development of the cathode ray tube by Ferdinand Braun.
1907	Use of cathode ray tube to produce television images.
1923	Patent for the iconoscope, the forerunner of the modern television picture tube.
Early 1930s	RCA conducts black and white broadcasting experiments.
1936	First television broadcast made available in London.
1938	Initial proposal for color television broadcast made by George Valensi.
1949	System developed to transmit chrominance and luminance signals in a single channel.
1950s	Hollywood looks to recover profits lost to television by introducing such formats as 3D and Cinemascope.
1954	NTSC standard for color television broadcast introduced in the United States.
1966	PAL standard introduced in Europe.
1975	Sony markets the first Betamax VCR for home viewing and recording of video.
1976	JVC introduces the VHS format to the VCR arena.
1976	Dolby Laboratories introduces Dolby Stereo for movies.
1978	Philips markets the first video laser disc player.
1984	The first Hi-Fi VCR is introduced.
1985	The broadcast of stereo television.
1994	Standard agreed upon for high definition television (HDTV) transmission.

1.2.2 Broadcasting Service

The broadcasting service is used to serve both international and domestic audiences. International audiences are served by *external service* which are mostly short wave radio transmitters. Domestic audiences are served by *home service* over-the-air radio and television systems. This service is also the major source of local news, sports, public affairs, etc.

1.2.2.1 External Service

External service by its very nature requires the generation of signals that are intended to be transmitted across international borders. Consequently, transmission of these signals is subject to the ITU (International Telecommunication Union) Radio Regulations. For decades, governments have made increasing use of the electromagnetic spectrum to conduct public diplomacy by broadcasting speech and music throughout the world. The *external service* stations are administered by All India Radio in India and these are broadcast overseas on various Medium and Short Wave frequencies depending on the time of day and season of the year. These broadcasts are made in 16 foreign and 8 Indian languages, directly to receivers used by individuals throughout the world. The main external service transmitter at Bangalore has 6 nos. of 500 kW transmitters with slew aerials and rotatable curtains with 8 beams of 30 ^{0} width which practically covers whole of Asia and Europe. The External service transmitters in India are given in Table- 1.3

Table- 1.3

External Broadcast Transmitters in India

Location	Numbers	Power of each transmitter
Short Wave Transmitters		
Aligarh	4	250 kW
Bangalore	6	500 kW
Delhi	2	250 kW
Gorakhpur	1	50 kW
Panaji	2	250 kW
Medium Wave Transmitters		
Calcutta	1	1000 kW
Jallandhar	1	100 kW
Rajkot	1	1000 kW
Tuticorin	1	200 kW

The analog high frequency transmissions suffer from distortion and fading in the ionosphere, from congestion in the bands and deliver an audio quality that can at best be described to be approaching that of medium frequency band. The ionospheric propagation also gets affected by solar emissions, viz. sunspots, solar flux and solar flares [3]. Against this background, International broadcasters are examining the potential of delivering digital radio programmes in future to audiences world-wide as a direct to home (DTH) service using satellite. A consortium for DRW (Digital Radio World-Wide) has been set up in 1994 to address this issue [4].

1.2.2.2 Home Service

In India, domestic audiences are served by AM, FM, and TV broadcast stations employing analog radio transmissions designed for direct reception by home receivers. Indian households are well served with 180 million radio sets and 55 million television sets in 152 million households. The coverage by population is 97.5 % for radio and 85.8 % for TV. This is done by 171 MW, 50 SW, 94 FM and 792 TV transmitters in the country as on March 1996. All India Radio also operates a national channel with a 1000 kW transmitter at Nagpur supplemented by 2 X 10 kW medium wave and 2X3 kW FM transmitters. The national channel is an attempt to cover the country for a unified programme. The coverage by national channel is 80% by population and is shown in Fig. 1.1. The service is provided only during night time.

1.2.2.3 AM Broadcast Stations

AM broadcast stations operate on a channel in the 531-1602 kHz AM broadcast band. This band consists of 120 carrier frequencies beginning at 531 kHz and progresses in 9 kHz steps to 1602 kHz. The modulation of the carrier wave is in terms of it's amplitude; hence, the AM reference. There are 175 AM broadcast stations operating in India. The operating power ranges from 1 kW to 1000 kW. Propagation in the AM broadcast band involves both the ground wave and skywave modes. The ground wave and skywave modes of AM broadcasting stations serve local and distant audiences, respectively. A disadvantage in AM broadcasting is its limited audio fidelity, relative to FM.

FIG. 1.1 COVERGE BY NATIONAL CHANNEL OF ALL INDIA RADIO

1.2.2.4 FM Broadcast Stations

FM broadcast stations in India are authorized for operation on 80 allocated channels, each 180-kHz wide, extending consecutively from 100 MHz to107.9 MHz with standard deviation of 75 kHz. The effective radiated power ranges from 6 kW to 10 kW. 94 commercial and noncommercial FM stations are currently being operated by All India Radio. Better audio fidelity is a distinct advantage of FM radio over AM radio broadcasting; however, FM radio does not normally have the extensive service coverage areas that AM radio broadcasting enjoys. In India, the FM stations are normally operated to serve a small area of about 35-50 km (radius) and they are termed as Local Radio Stations (LRS). The distribution and the coverage areas of LRS in India are shown in Fig. 1. 2.

1.2.2.5 Television Broadcast Stations

Throughout India, commercial and educational television broadcast stations comprise the broadcast television organization. These stations operate on 6-MHz wide channels in the VHF and UHF frequency bands. The spectrum occupied by television broadcast comprises 72 MHz in the VHF band and 336 MHz in the UHF band. The Television network in India is given in Table 1.4

Table 1.4

Television Network in India

High Power Transmitters	77
Low Power Transmitters	526
Very Low Power Transmitters	120
Programme Production Centres	34

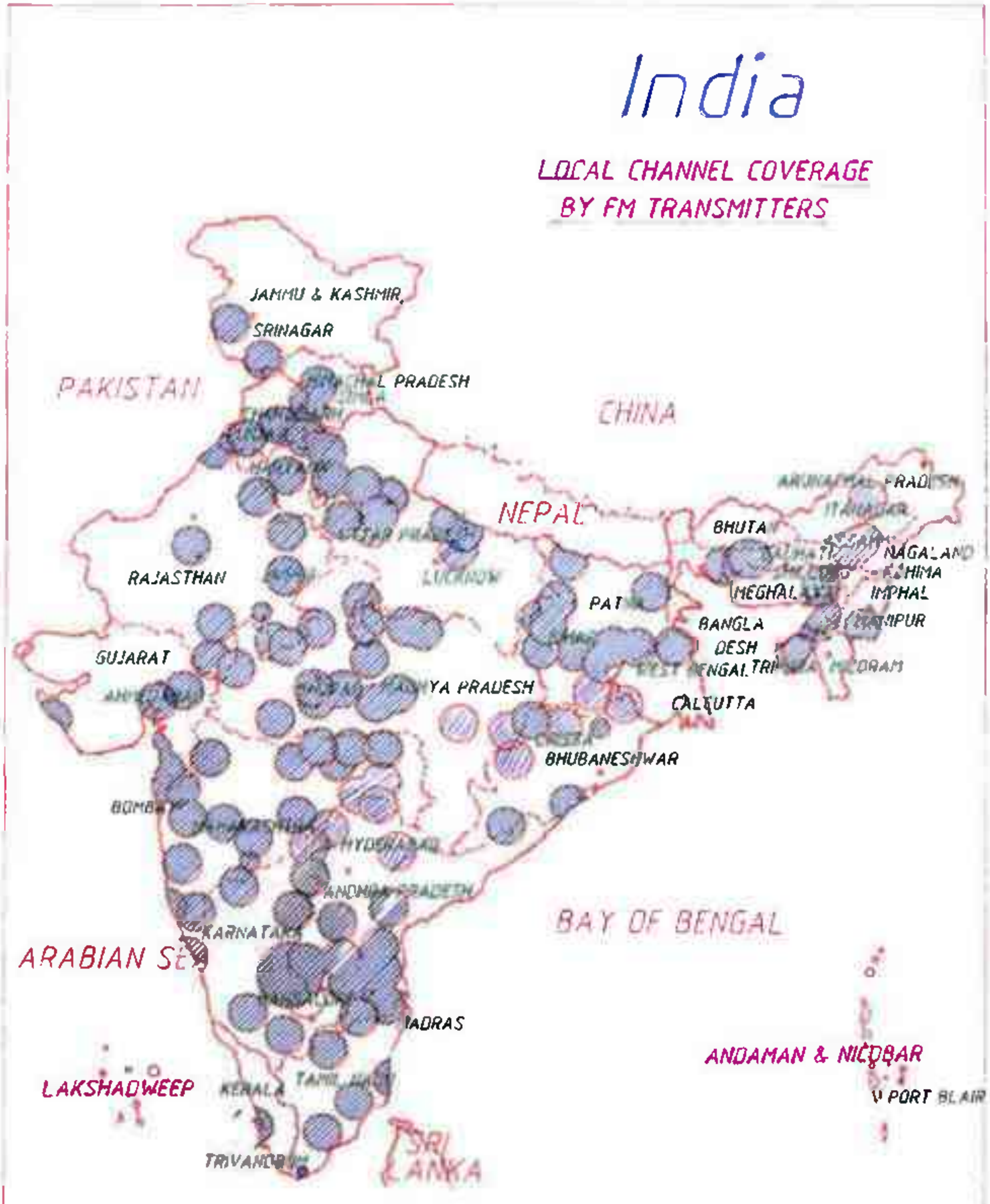


FIG. 1·2 COVERAGE OF FM LOCAL CHANNELS OF ALL INDIA RADIO

1.3 New Technology Frontiers In Broadcasting

Developments in digital coding, modulation, and compression have made the transmission of digital audio commonplace and digital video feasible. These technologies are gradually making their way into the conventional broadcasting scene as digital audio and ATV. The potential exists for an enhancement to AM and FM broadcast stations where the sound quality can equal or nearly equal that of CD-technology. Also, HDTV is being developed in the United States, Europe, and Japan as a means of providing greatly improved picture quality to television viewers. The development of a successful HDTV system will provide the basis for revolutionary new video services to many homes, industry, scientific, and medical organizations. The implementation of HDTV is difficult and expensive for broadcasters, but it appears essential for broadcasters to find a way to upgrade their facilities to provide HDTV to consumers and remain competitive with the virtually certain introduction of HDTV by cable, VCR's, and DBS. International broadcast stations will experience improved spectrum efficiency with the planned single-sideband implementation and with satellite-sound broadcasting potentially representing a supplemental delivery system to international audiences. The technology has reached to the point where digital sound and picture are broadcast quality and economical. A technology demonstration of all digital production and transmission was done in the International Broadcasting Convention (IBC) - 1995, held at Amsterdam [5]. The DDS (Digital Delivery System) was capable of providing up to 16 simultaneous stereo replay channels in either linear or MPEG-2 format.

Thus broadcasting in recent times is undergoing a phenomenal change. The recent technological trends in new broadcasting systems are briefly discussed below.

1.3.1 Studio Technology

The broadcast process consists of initial recording/shooting, post production and distribution (Fig. 1.3). Initial production involves studios, OB vans, etc. Post production consists of editing, layering, modification of picture contents and adding audio/video effects while distribution consists of actual delivery via terrestrial transmitter, satellite or cable. The limitation of analog technology with regard to the number of copies and layers is not the only drawbacks. The tape recorder needs time to play, record, wind and rewind the tape to find the desired clip. The digital video/audio server and disk recording technology provide random access, ease of editing and post production.

In most digital broadcast installations, the system is built around a central signal distribution unit. This equipment receives various signals from internal and external resources. The internal resources are live / recorded material. The external resources are OB vans, databases, value-added signals, networks etc.

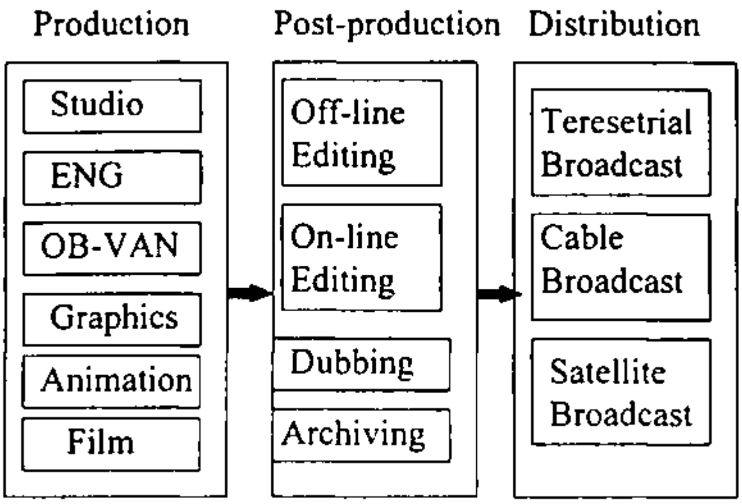


Fig. 1.3 Broadcast Processes

1.3.1.1 Evolution of digital broadcast signal format

PAL, SECAM, and NTSC standards were adopted for composite colour signals in 1960's for maintaining a compatible reception by millions of black and while TV sets. To keep the same channel allocation and to save the frequency spectrum, same black and white channel bandwidth were used; approximately 4.2 MHz for NTSC and 5.5 MHz for PAL/SECAM. Such a low bandwidth were found adequate for transmission to the TV receivers, albeit with drawbacks like "cross colour' in specific conditions [6]. However, these were not sufficient for processing in the studios; i.e. for chroma keys (Table 1.5). This led to the evolution of component standards in 1981, which are commonly known as "Betacam" and the "M" format. This analog component standard had the disadvantage in the post production that it needed three cables for every signal instead of one for the composite. For all these reasons, it was necessary to use

Table 1.5

Chroma Keying

Image origination sources such as camera and telecines , internally produce colour pictures as three full bandwidth signals: one each for green, blue and red. Capitalising on human vision not being as acute for colour as for brightness level, television signals are generally transformed into luminance (Y) and colour difference signals (R-Y, B-Y). Chroma signal is derived from the colour difference signals. Composite video is obtained by encoding of Y with Chroma signal (See Fig. 1.4).

a digital television standard that would make it possible to preserve the original quality whatever the processing complexity. CCIR 601 (usually referred to as 4:2:2) was defined as an international standard for component coding of TV signals [7]. It specified orthogonal sampling at 13.5 MHz for luminance (Y) and 6.75 MHz for the two colour difference signal Cb and Cr.

Some extended definition TV (EDTV) systems use a higher resolution format called 8:4:4 which has twice the bandwidth than that of 4:2:2. The choice of sampling frequencies gives 720 samples / active line for luminance (Y) and 360 samples for colour differences and also includes space for representing analogue blanking within the active line. A serial digital signal for carrying the signal on a single coaxial line was developed in 1984. The system was standardized for 243 Mbits/sec based on 8/9 bit transcoding (coding from one standard to other). Subsequently a serial digital component standard based on 10 bit was developed [8]. Fig. 1.4 shows the video format summary.

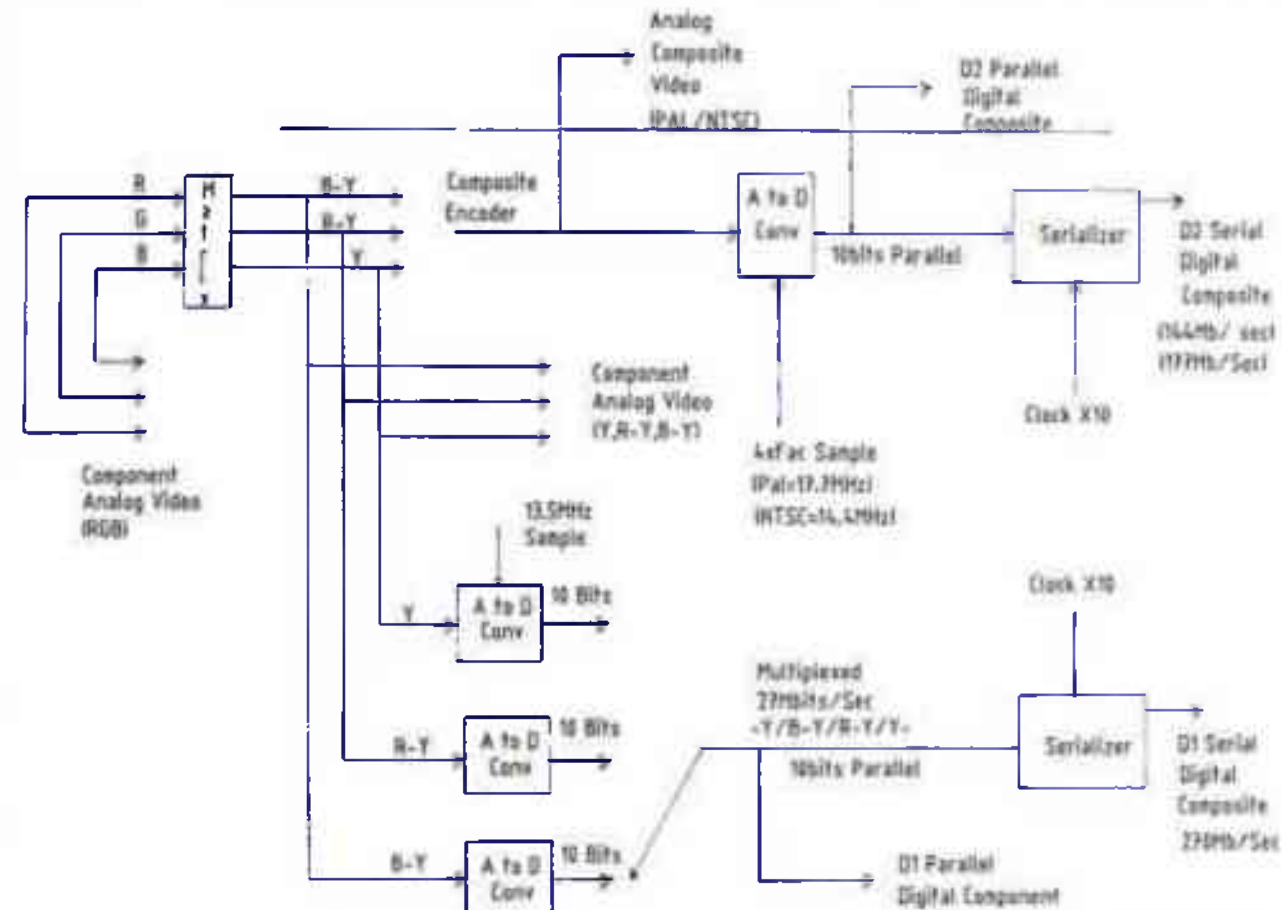


Fig. 1.4 VIDEO FORMATS SUMMARY

1.3.1.2 Storage Devices

With the advent of personal computers in the early 80's, a vast amount of data started being generated in the digital form. Consequently, a need was felt for accessing and searching quickly and interactively the huge data so created. There was also a mounting concern for long-term storage of this information and its distribution. There were a number of contemporary storage media, ranging from removable floppy diskettes and magnetic tapes to fixed hard disks, which promised to address this issue. But all of them had their drawbacks. Floppy had a relatively small storage capacity and shelf life. Fixed hard disks were expensive option as more and more drives with higher storage capacity had to be installed to cope up with the growing amount of data. Magnetic tapes were removable with a higher storage density but apart from being susceptible to wear and tear, they offered serial access only.

With the digital format of broadcast signals, a vast amount of data was required to be stored for which all above devices were not suited. Even with the advent of compression standard, the data required to store one movie was huge enough to store on any one of these devices (Table 1.6). The entire concept of digital post production and delivery is based on the quality and capacity of storage devices. Therefore storage devices play important role in digital broadcasting. There has been fast development in the storage devices during last 10 years. Few devices used in broadcasting are discussed below.

Table 1.6

For 625 line TV standard, the active picture is: 720 pixels (Y) + 360 pixels (Cr) + 360 pixels (Cb) = 1440 pixels / line

576 active lines/ picture means 1,440 X 576 = 829,440 pixels / picture

Sampling at 8 bits, the picture takes 829,440 bytes or 830 kBytes of storage.

1 sec. takes 830 X25 = 20750 kBytes ≅ 21MB

1 min. takes 21 X 60 = 1.26 GB

1 hr. takes 1.26 X 60 ≅ 76 GB

After compression also, it is roughly 3GB/hr.

1.3.1.2.1 DAT (Digital Audio Tape)

Developed in 1985, digital audio tape had two recording methods viz. R-DAT (rotary head digital audio tape recording) and S-DAT (stationary head digital audio tape recording). Finally R-DAT was standardized. R-DAT uses digital format with a sampling frequency of 48 kHz and linear 16 bit quantisation [9]. With an absolute tape speed of 8.15 mm/s, the R-DAT requires only 60 meter of tape for two hour playing time. The digital audio signals yield a data stream of about 1.5 Mbits/sec. Special sections within the track are reserved for auxiliary information, viz. programme titles and time codes. The main disadvantage of DAT is lack of random access capability.

1.3.1.2.2 Optical Technology

The optical technology makes use of light - both visible and infrared - to handle data processing information. The optical storage system includes MD, DCC, MOD, DAT and CD with storage capacities of 2.5, 4.0, 3.5, 13 and 15 Gbit respectively. The feasibility of using optical technology for recording audio /video signal was demonstrated during 60s at the Stanford Research Institute, USA by recording 30 minute analog, black and white TV programme on a high resolution photographic disc of 30 cm diameter. A high pressure mercury vapor lamp was used as the light source for recording[10]. Philips in Netherland introduced Laservision discs in 1972. These 30 cm diameter discs could produce hi-fi sound and video using laser scanning of the recorded data. Technology further got improved and Sony together with Philips in 1980 came up with the first set of standards for audio CDs, including size and encoding format. The CD audio was a 12 cm disc with 72 minutes of audio recorded on it. The present CD ROM are the improved version of CD audio.

1.3.1.2.2.1 CD ROM (Compact Disc - Road Only Memory)

Introduced in 1983, CD ROM is cheap in quantity, durable, unaffected by magnetic disturbance and free of most hazards that prey storage media. Ultimate in audio excellence, the CD format is a real time, 16 bit linear pulse code modulation (PCM) process and supports a wide bandwidth of 20 kHz. Compact Discs are 12 cm in diameter, just over a mm thick, weigh about 16 grams and store upto 680 MB of data consisting of text, images, sound and graphic. The data is stored in the form of microscopic pits about half a micron wide, arranged in a single spiral track starting from inside to outside (total length of about five kilometers). A CD contains about 5 billion pits [11]. It's principle limitation is read only nature and the enormous amounts of storage space and circuit bandwidth it occupies. The seek /access time for a CD ROM is 180 ms. (Hard disk - 10 ms).

The data transfer rate for a double speed CD ROM drive is 300 kB/s (Hard Disc - 2 MB/s). The technical specifications of a CD are given in Table 1.7.

CD ROM drives and audio CD players use the same modulation as well as error detection systems. They have same physical dimensions and composition. They use same physical mastering and replication process. However one lost bit of an audio CD won't affect the sound reproduction but it can be catastrophic for data stored on a CD ROM. As such CD ROMs have an extra level of error correction and detection.

Table - 1.7

Technical Data for CD system

Disc	
Diameter	120 mm
Thickness	1.2 mm
Reading Speed	1.2 to 1.4 m/s
playing time	max. 60 min (stereo)
Signal	
sampling frequency	44.1 kHz
Quantisation	16 bit linear per L/R channel
Data rate from disc	4.3218 Mbps
Audio performance	
Frequency range	20 Hz to 20 kHz; ± 3 dB
S/N Ratio	>90 dB

1.3.1.2.2.2 CD-R (CD Recordable)

Compact Disc Recordable (CD-R) or CD-WO (Compact Disc Write Once) available since 1989, use a layer of organic dye and a very thin layer of reflective gold on a pre-grooved polycarbonate disc. The dye polymer, when exposed to a cutting laser beam, reacts with the polycarbonate to form a pit. This pit is read as any other CD ROM. The CD-R can be written in multiple session.[12]. Discs with storage capacity of 550 MB are now available.

1.3.1.2.2.3 Compact Disc Interactive (CD-I)

CD-I is capable of playing upto 72 minutes of moving pictures on full screen with audio of Compact Disc quality. A typical full motion CD-I disc allocates 1.2 Mbps for video and 0.2 Mbps for audio in stereo quality. In order to compress the audio/video to this bit rate (1.4 Mbps), the MPEG coding is used. During playback, the audio/video is decoded. The main features are 50/60 Hz compatibility and high quality full motion play back of 72 minutes duration [13].

1.3.1.2.3 Digital Video Disc (DVD)

DVD are capable of storing about 2 to 10 GB data on a single disc. This is done by decreasing the size of the pits as well as the distance between them and utilizing advanced compression techniques. A single DVD of 12 cm can store two to five hours of high quality video .

It is desirable to have two or more hours of recording (one movie) on a 3 GB DVD. With the requirement of 6 Mbps of MPEG-2 in constant bit rate (CBR), about one hour of recording is only possible. As a solution, a variable bit rate (VBR) coding which permits 3 Mbps with sufficient picture quality is used. Coding and multiplexing is still based on MPEG-2 method (ISO/IEC-13818-2) which supports VBR [14]. Main-Profile at Main-Level for video and Program Stream for Multiplexing is used. Audio signal is coded in CBR [15].

1.3.1.2.4 Video Servers

The video server is the storage device which includes computer network and SCSI (Small Computer System Interface) to distribute and archive compressed video as data, avoiding generation losses and taking advantage of standard computer network and tape transports.

The unprecedented expandability of the video server is made possible through the invention of a low cost scaleable interconnect called the Data Transport Commutator which makes all of the arrays in a system appear as a single pool of video and audio to each channel. Only a single copy of any video or audio segment is needed and all channel have simultaneous access to it. This interconnect is a high speed switching network which allows the server to be scaled [16].

A video server can be represented by five key components: i) RAID disk array, ii) a real time controller for traffic management on the bus, iii) I/O cards, iv) high speed internal data bus, and v) disk scheduling that configure the video server for specific applications [17].

Video server must contain storage, and a common choice today is magnetic hard disk. While in nonlinear editors, a single disk may be used to store the compressed video as it is digitized, broadcast applications differ in two fundamental respects. One, broadcast applications demand and multiple, simultaneous channels accessing the same material and two, data protection. Disk arrays with RAID satisfy both these requirements [18].

1.3.1.3 Robotic Tape Handling Systems

In a bid to automate the broadcast studios, the recent trend is to load the tapes into robotic tape handling systems including videocarts [19] (a device that stores a number of tapes and passes it to digital recorders for on-air transmission on the basis of program entered in a remote computer). Playback is triggered by a computerized signal sent from the broadcast automation system. Back-up videotape playback equipment ensures uninterrupted transmission at all times.

1.3.1.4 Non Linear Video Editing Systems

Non-linear system allows editing of a video by feeding the raw footage from tape on to the hard drive of the computer disk. Video clips on the disk can be manipulated using a software much like the text being edited by a word processor. With the help of a mouse, the clips can be moved and shuffled around a time-line. The provision for inserting digital effects including graphics, lighting, transitions such as dissolves, wipes, peels, page turns etc. also exists. The latest high end editing suites allow real time transitions. The typical systems are based on card that includes a dual M-JPEG codec card, a digital graphics mixer with 2D digital video effects (DVEs), a multichannel analog video I/O board, Q-MPEG-2, a four channel MPEG-2 decoder, and an Active Movie Development kit. The main features are Windows editing system, true lossless compression of

CCIR-601 video at the maximum quality setting (1.6:1), as well as onboard Fast and Wide SCSI (Small Computer System Interface) controllers and the Movie 2 bus for connection to compatible devices such as effects card. The codecs are on daughtercards, enabling future upgrades. [20].

Fig. 1.5 shows a hard disk based workstation for non-linear editing. The screen shows a montage of many different shots, each of which appear in a window. The screen is refreshed by a framestore which is read at the screen refresh rate. These shots can be edited independently. The background scenes, titles, captions etc. can also be entered. After the individual shots have been edited to perfection, these are brought to a time-line on a separate window and assembled. Any window can be activated at any time. The editing may be done on-line or off-line. Once the editing is finished, the video can be recorded back on the original media. In large broadcast systems, the edited work can be broadcast directly from the disk file server. In smaller systems, the output is taken to a removable medium [21].

A non-linear editing console is shown in Fig. 1.6. The blow up of the editor is shown in Fig. 1.7. The decks are shown in the side rack. With tools such as a non-linear editor with drawing tablet, and with software packages like Fractal Painter, Autodesk 2D, Animator 3D studio and Elastic Reality, almost any type of edit operation is possible.The colorful keyboard not only works on the computer, but can be used to control the decks as well.

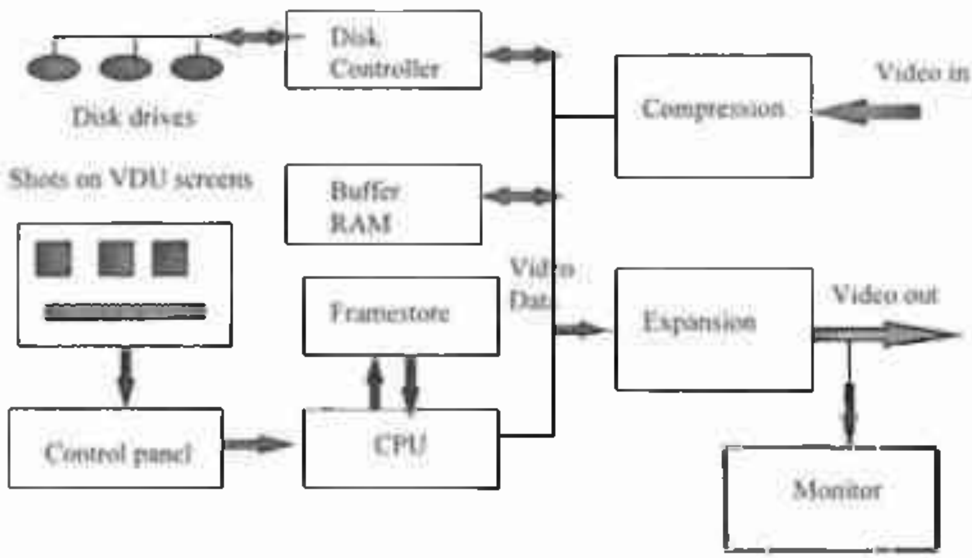


Fig. 1.5 Hard disk based workstation for non-linear editing

Fig. 1.6 Non-linear Editing Console

Fig. 1.7 Blow up of editor

1.3.1.5 The Virtual Reality

Virtual Reality (VR) is defined as an experience in which a person is surrounded by a three dimensional computer generated representation, and is able to move around in the virtual world and see it from different angles, to reach into it, grab it, and reshape it [22]. The Virtual Studio attempts to integrate computer and information technologies into the very heart of architecture design. The virtual studio system combines live video with 3D computer generated graphics set in real time, during live-to-air or live-to-tape shooting. The use of 3D computer generated graphics sets eliminates the need for the physical props. These graphic sets integrate broadcast quality images [23]. The system also permits insertion of video clips, interactive 3D effects and scenarios, visual and audio reactions and more [24].

Virtual studio is made up of rear-projection screens for walls and a down-projection screen for the floor. Projectors throw full color workstation fields (1280 x 512 stereo) at 120 Hz onto the screens, giving between 2,000 and 4,000 linear pixel resolution to the surrounding composite image. Computer controlled audio provides a sonification capability to multiple speakers. A user's head and hand are tracked with electromagnetic sensors. LCD stereo shutter glasses are used to separate the alternative fields going to the eyes. High end workstations create the imagery (one for each screen); the output is connected via serial communication port to input devices and synchronization via fiber optic reflective memory. The projector optics are folded by mirrors. With the advancement of multimedia and 3D graphic supported computer systems, the virtual reality is being produced by mixing the stored scenes with the real actors or virtual actors with the real scenes [25]. Virtual Studios are opening very exciting possibilities where the shootings can be made in the studio and thereafter the scenes from the digital stores can be added. This will offer lot of economy in video production. Mona Lisa (Modeling NaturaL Images for Synthesis and Animation), a collaborative project undertaken by nine European industrial, broadcasting and academic institutions and supported by European Union to address all the key aspects of virtual studio operation, demonstrated the exciting possibilities in 1995 [26]. Subsequent to this demonstration, a number of broadcast organizations have setup the virtual studios [27,28].

1.3.1.6 The Global Studio

The Global Studio is a collaborative exercise which involves the participation of a number of people distributed over the internet. This allows artists located in different cities or countries to participate in programme production without really being present in the studio.

1.3.1.7 Signal Processing

Broadcast "signal" is a time or space dependent quantity that contains information. Examples of a time signal are music or the spoken word. An example of a space signal is a video (television) image. Signal processing comprises of implementing strategies for decomposing information into parts, removing noise from information, channel equalization and echo cancellation. Channel equalization, which balances the channel response across all frequencies, is necessary to make high speed (megabits per second) transmission of data. New high speed modems are incorporating ever more sophisticated channel equalization algorithms [29] to enable higher transmission speeds. Furthermore, testing is on going for ghost cancellation systems for broadcast television [30]. Ghost signals which are undesired images due to multipath reflections are eliminated by using special circuits to detect multiple signals and thereafter suppressing it by special filters.

Array signal processing is entering the marketplace for use in systems where speech signals must be extracted from noisy environments and active noise cancellation for cars, airplanes and factories. Signal processing has dramatically improved in recent times due to availability of advanced technology viz. programmable hardware and software digital signal processors (DSPs) [31], parallel machines, VLSI synthesis and advanced software environments.

1.3.1.8 Digital Quality

It is worth while to know the quality expectations for the digital system. The digital system will provide an increased signal to noise ratio of the order of 98 dB for 16 bit system { SNR = (6.02 x n) + 1.76, where n is the no. of bits per sample} as compared to 65 dB of analog audio [32] and no deterioration and multi-generation tape loss when it comes to long term archiving. However these data are for the uncompressed digital audio. The representation of digital image needs a vast amount of data. For example, with a sampling rate of 48 kHz and 16 bit linear coding, a stereo signal has a source data rate of about 1.5 Mbps. Assuming a base bandwidth of 45 MHz, threefold sampling frequency and a resolution of 8 bits, a HDTV signal features a data rate of 1.152 Gbits/s. The direct transmission of such data rates for audio and video would not be viable economically. To solve these problems, new ways are being followed at the expense of perfection. At the destination (receiver), the signal is not reproduced but psychoacoustics and visual phenomena is used to recover the signal that may be optimum for listening /viewing.

In a digital domain, a photo can be scanned digitally and transmitted as a serial bit stream. In order to reduce the time of transmission, it is desirable to transmit as few a bits as possible. Certain algorithms can be used to discard the transmission of redundant bits and reconstruct it at the receiving end. The Television signals have substantial redundancy in them. This means one frame looks much like the next in most cases. This is called temporal redundancy. Even within a frame the video samples are to some extent predictable. This is called spatial redundancy. Eliminating temporal and spatial redundancy in television results in less number of bits to be transmitted. This is called compression of video signal. The Motion Picture Expert Group (MPEG) defined MPEG-1 standard [33] in 1992 and MPEG-2 in November 1994 [34] for moving video. In video compression, signal processing algorithms separate video signals into constituents, enabling digital encoders to efficiently represent these singles for transmission. Video receivers need similar systems to reconstruct the picture. In this way audio data can be reduced by a factor of eight without affecting the CD quality, and HDTV data by a factor of seven to fifty (140 to 20 Mbps)[35]. Since the reception quality depends upon the extent of compression, a concept of hierarchical quality structure has emerged for digital TV [36]. HDTV or High Definition TV is for very high quality viewing in a big hall. EDTV or Extended Definition TV is also high quality viewing in home. SDTV or Standard Definition TV is the quality available today. LDTV or Low Definition TV is for mobile service, viz. for a train or car. Table 1.8 shows the hierarchical quality structure for compressed digital TV signals. Quality categorization of digital broadcast signals is given in Fig. 1.8.

Table 1.8

Hierarchical quality structure for digital TV

Format	HDTV	EDTV	SDTV	LDTV
Quality	High	Enhanced	Standard	Limited
Comparable to	2XCCIR601	CCIR601	PAL /SECAM/NTSC	VHS
Data rate before compression	1.152Gbps	432Mbps	216Mbps	108Mbps
Data rate after source coding	30Mbps	11Mbps	4.5Mbps	1.5Mbps
Compression	MPEG-2	MPEG-2	MPEG-2	MPEG-1
Utility	Telepresence	Home viewing	Home viewing	Mobile TV

1.3.1.9 Towards All Digital Studio

All these developments have led to the concept of all digital studios. DAWs (Digital Audio Workstations) and Video Cart becoming everyday broadcast production tools, non-linear editing coming to age and HDTV edging closer to consumer reality, all digital television production and distribution is not far away.

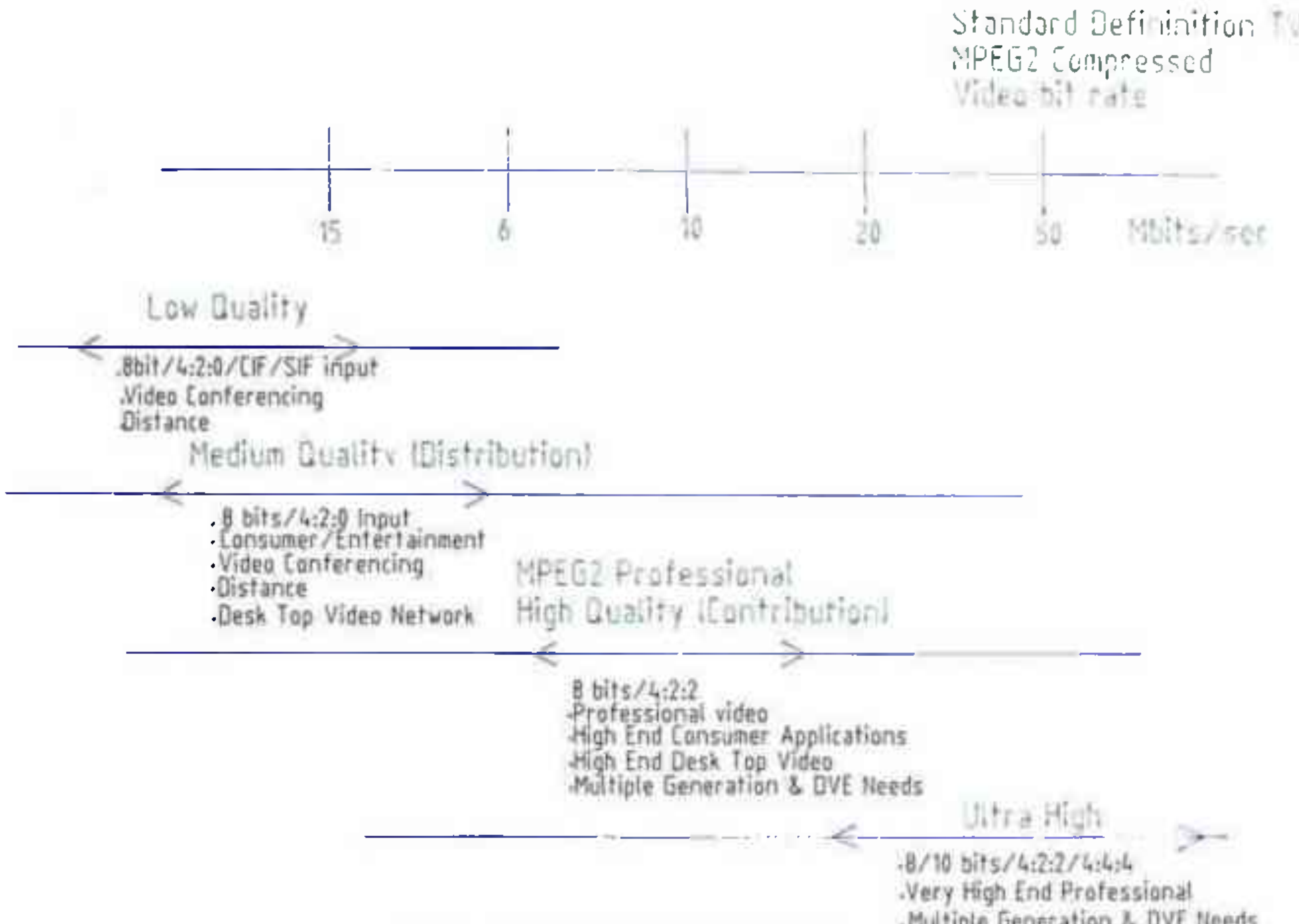


FIG. 1-B QUALITY CATEGORIZATION

1.3.2 Transmission System

Transmission system in the broadcast scenario deals with the distribution of signal via terrestrial, satellite or cable. Till early 90s, the main delivery of broadcast signals was through terrestrial analog transmitters. The satellites were used for linking of terrestrial transmitters. The development was mostly towards increase in efficiency and signal quality. The recent trend is towards digital broadcasting using terrestrial modes or direct satellite broadcasting for the direct to home service. In the following sections, few of the latest developments taking in this area have been described.

1.3.2.1 Digital Audio Broadcasting

The prospect of sending higher quality audio to portable receivers is spurring development of digital audio broadcasting (DAB) [37]. Europe has led the way with its Eureka 147 project [38]. The project was launched in the year 1986 and continued up to 1994. The main emphasis of the project was to carry out test DAB transmissions and also consider the new communication services supplementary to the broadcast services (traffic information and management system, data transmission to specific group of users etc.) The DAB was carried out using channel coding and interleaving. With terrestrial multipath propogation, signal fading takes place resulting in burst errors. To eliminate this, the transmitted bits are interleaved in the channel coding so that the burst errors are split into individual bit errors which can be corrected by the channel coding. OFDM (Orthogonal Frequency Division Multiplexing) [39,40,41] was used and six stereo programmes were transmitted with other data (Fig. 1.9). The system *used ISO/MPEG1 layer 2 audio coding for source coding.* The project led to the detailed and comprehensive system definition and specification of the standards [42,43,44]. The general specification of DAB transmission system is given in Tables 1.9. Japan started DAB satellite services in 1992 for small fixed panel antennas. BBC started its introductory DAB service in

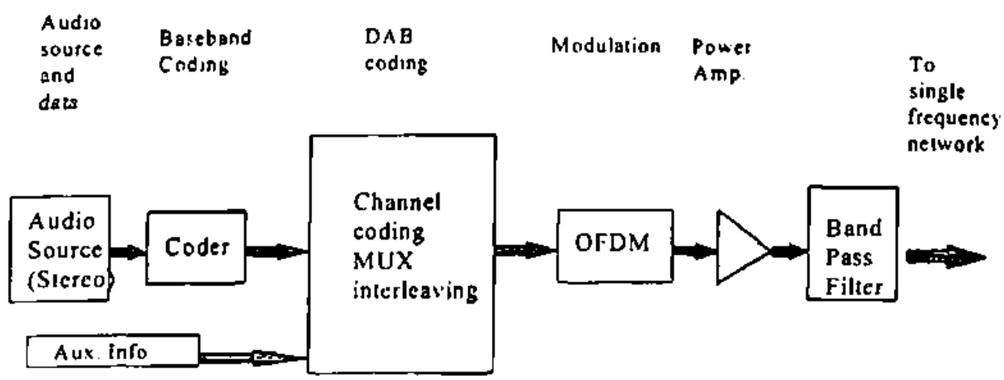


Fig. 1.9 Block Diagram of a DAB transmission System for mobile reception

Table 1.9

General Specification for DAB Transmission System

Transmission Mode	I	II	III
Application	Terrestrial	Terrestrial	Satelite /Cable
Nominal freq. Range	<= 375 MHz	<= 1.5 GHz	<= 3GHz
Carrier no./space	1,536 / 1kHz	384 /4 kHz	192 / 8kHz
Guard Interval duration	246 μs	62μs	31μs
transmission frame duration	96 ms	24 ms	24ms
Bit rate	2.4 Mbps	2.4 Mbps	2.4 Mbps
System bandwidth	1.536 MHz	1.536 MHz	1.536 MHz

September 1995 in the frequency range 217.5 - 230 MHz. All India Radio is conducting experiments with DAB in Delhi. A 125 Watt transmitter has been installed and the field trials have just began. Broadcasters are investigating technologies to enable digital transmissions to share the same spectrum with existing FM and AM broadcasts. The advantages to the listener of the DAB system over FM are very impressive. The sound quality is comparable to that of CDs and is relatively immune to multipath interference. Data such as lyrics and phone-in numbers can also be transmitted with the audio. Programme labeling, graphics and traffic messages are among the other enhanced features available. A block diagram of a DAB receiver is given in Fig. 1.10 [45]. The programme selection is done by a D-OFDM and a D-MUX. This is followed by DPSK demodulation and a MUSICAM (Masking pattern adapted Universal Subband Integrated Coding And Multiplexing) decoder. DAB is much more spectrum efficient since a single frequency can be shared for the whole of the national terrestrial network.

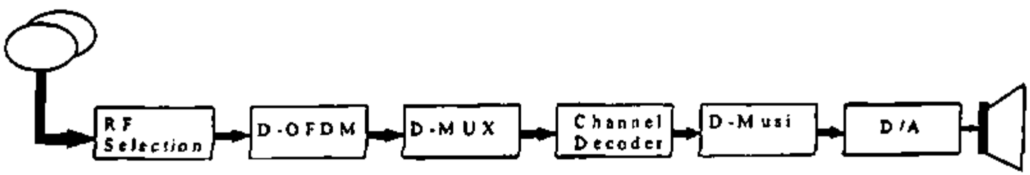


Fig. 1.10 Block Diagram of a DAB Receiver

1.3.2.2 High Definition Television (HDTV)

Around the world, High Definition television (HDTV) systems are being brought to the fore. Similar to the quality of sound gained from the compact disc (CD) HDTV sets a standard, in which picture quality is comparable to the clarity of 35 mm film. The standard for analog HDTV was defined in 1970 with 1125 lines scanning rate, line interlacing, 5:3 aspect ratio and 60 Hz field frequency. The trials were conducted in Japan using satellite in 1989 and the experimental transmission started in 1991[46]. Japan has begun limited satellite transmission but high receiver costs combined with lack of HDTV programmes are resulting in limited penetration. In Europe and Japan, the emphasis was initially on analog satellite transmission. *In the USA, the Japanese standard with 1125 lines /60 Hz* was accepted. However, there was the problem of terrestrial TV channels having a bandwidth of 6 MHz and priority being given to terrestrial programme distribution over other transmission media. An advisory Committee formed in 1987 by the Federal Communications Service (FCC) in USA for evolving technical standards for Advanced Television Service [47,48] was entrusted the job of laying down standards for HDTV in 1990. The field trials for digital HDTV using terrestrial transmitters [49] and cable [50] were initially conducted in USA in 1991. With the availability of compression techniques, Europe also started experimenting with Digital HDTV in 1991 [51]. An experimental HDTV broadcast through a single 6 MHz terrestrial channel was successfully made in USA in May 1992 [52]. China made experimental broadcasts of HDTV in 22 Mbps in 1993 [53]. The recommendations of advisory committee of FCC was finally made available in Feb. 1993 [54,55,56,57]. The advisory committee recommended that HDTV on analog system may be dropped. They also recommended implementation of digital HDTV in 6 MHz channel. However, further improvements were necessary and this lead to the formation of "Digital HDTV Grand Alliance" in May 1993. The grand Alliance is a consortium of HDTV proponents formed at the request of the FCC to design and build a prototype HDTV system on which the FCC would base its HDTV broadcast standard. The Grand Alliance initiated extensive laboratory and field tests on the Digital HDTV System in 1994 and prepared the system specification for Digital HDTV [58]. Final standards were issued by United States Advanced Television Systems Committee in April 1995 [59]. The efforts are on-going to evolve a common standard for HDTV [60].

Fig.1.11 shows the transmission chain for a HDTV broadcasting. The high quality interlaced or progressive video input is passed through a multi-format scan converter to get a digital video [61]. The digital signal of 1.152 Gbits/s is taken via a signal processing unit to the source encoder [62,63]. The output data rate of 30 to 20 Mbits/s is subjected to FEC and channel coding [64]. In the subsequent multiplexer, the audio, sink data and control signals are added to the coded picture signal, whereupon a gross data rate of 30 to 40 Mbits/s is obtained. MPEG-2 is used for video coding and AC-3 for audio coding. The channel coded data are modulated onto the IF carrier and packed into a channel bandwidth of 6 MHz (7 to 8 MHz in Europe). A mixer upconverts to the RF carrier frequency, e.g. in Band I to Band V (47 MHz to 862 MHz) before the signals are applied to the terrestrial transmitter and antenna.

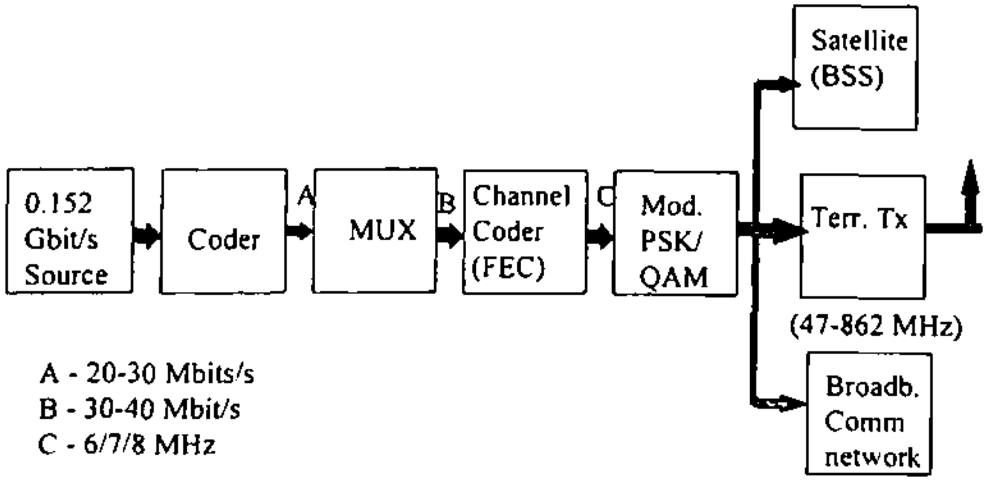


Fig. 1.11 Transmission Chain for Digital HDTV

In the receiver, signal processing is basically reversed [65]. Due to different channel transmission characteristics of the various media, the decoding and demodulation techniques are adopted accordingly. As such a single receiver is not suited to all the media. Efforts have also been made to develop HDTV decoders that may help receive HDTV signals on standard TV (SDTV) or monitors [66].

1.3.2.3 Direct Broadcast Service (DBS)

In the 1970's and 1980's satellite became a chief means of long distance radio-communication and facilitated worldwide TV program distribution in real time. In rural areas not serviced by terrestrial TV broadcast stations and cable TV systems, satellite signals made possible direct reception of TV from satellites by TVRO (TV Receive Only) receivers equipped with parabolic antennas with diameters between 2 and 5 meters. For almost two decades, TV programme delivery by satellite was done in the 4/6 GHz and 11/124 GHz bands. Doordarshan is using this technique to provide centrally produced programmes to Low Power TV (LPTV) stations. There are 526 LPTVs all over the country and the coverage area for each of them is about 15 km radius.

The developments in advanced radiocommunications technologies and the offer of improved radio-based services paved the way for direct TV and audio broadcasts from satellites (also known as Direct to home - DTH service). Today, three technologies have been aggressively developed, the direct broadcast service (DBS), BSS-HDTV (Broadcast Satellite Service- HDTV) and BSS-Sound.

The general concept for digital television transmission by satellite developed in Europe under Digital Video Broadcasting (DVB) project and resulted in a standard by ETSI (European Telecommunication Standard Institute) [67]. The system named DVB -S (DVB-Satellite) is intended to provide DTH multiprogramme TV services in the BSS and FSS (Fixed Satellite Service) bands and is addressed to consumer IRDs (Integrated Receiver Decoder) [68] as well as collective antenna systems (SMATV - Satellite Master Antenna TV System) and cable headend stations with a likelihood of remodulation [69].

Digital Television Services for DBS (also known as DSS- Direct Satellite Service) have been started / planned in many countries in recent years. There are currently three digital DBS services in North America [70] and one service in France in operation. Russia launched it's first DBS satellite (GALS) in Jan. 1994 to provide Television services to five different time zone in Russia [71]. Malaysia and India plan to start DTH service in late 1996. Japan proposes to launch first DTH service using Comunication Satellite in 1996 [72,73]. These services intend to provide 100 or more TV programmes using a single satellite.

Direct broadcast satellite (DBS) was introduced in U.S. in late 1993 for the delivery of conventional television programming directly to the consumer, using frequency of 12.2-12.7 GHz for the BSS. The DBS system consists of a small 18 *inch satellite dish*, a digital integrated receiver/decoder (IRD) which separates each channel, decompresses and translates the digital signal, and a remote control [74]. The dish never has to track the satellite so there's no waiting for the picture to come in [75]. DBS programming is distributed in USA by three high power HS 601 satellites (DBS-1, DBS-2 and DBS-3), co-located in geosynchronous orbit 22,300 miles above the earth at 101 degrees west longitude. Each satellite features 16 no., 120 watt Ku band transponders with DBS-2 and DBS-3 each configured to provide 8 transponders with DBS-2 and DBS-3 each configured to provide 8 transponders at 240 watts. DBS-1 delivers upto 60 channels of programming and approximately 20 channels of programming from USSB (United States Satellite Broadcasting). DBS-2 and DBS-3 are used exclusively to provide approximately 175 channels. Each one of the transponders on the DBS-1 satellite can send more than 23 Mbps of information per second to a DBS system. The DBS-2 and DBS-3 satellites are even faster, at around 30 Mbps each.

Programming comes from various content providers (CNN, ESPN, etc.) via satellite, fiber optic cable and/or special digital tape. Most satellite delivered programming is immediately digitized, and uplinked to the orbiting satellite. The DBS satellites retransmit the signal back down to every earth station, or in other words, every little DSS receiver dish at subscribers' homes and business.

DBS employs MPEG-2 technology and QPSK modulation [76]. DBS is fully digital and "forward compatible" so that consumers can take advantage of emerging technologies, such as interactive services, 16 x 9 wide screen and HDTV (digital) broadcasts [77]. A DTH service using DSS is shown in Fig. 1.12.

Broadcasting Satellite Service-HDTV is meant for HDTV but due to the problem of large bandwidth required for analogue HDTV, the service has not become operational. WARC is a forum of ITU which is responsible for coordinating radio frequency for the countries. WARC-92 have allocated two frequencies: 17.3-17.8 GHz for Region 2 (Europe); and 21.4.22.0 GHz for Regions 1 (America) and 3 (Asia) for this service. These new allocations will become effective from April, 1, 2007. [78].

Broadcasting Satellite Service-Sound (BSS-Sound) is for high quality audio programming. BSS-Sound generally refers to the delivery of music, sports, news etc. directly to consumers' radio via satellite. WARC-92 adopted three different allocations for BSS-Sound:1452-1492 MHz, 2310-2360 MHz and 2535-2655 MHz. The service shall be received using portable radios. Such services will not

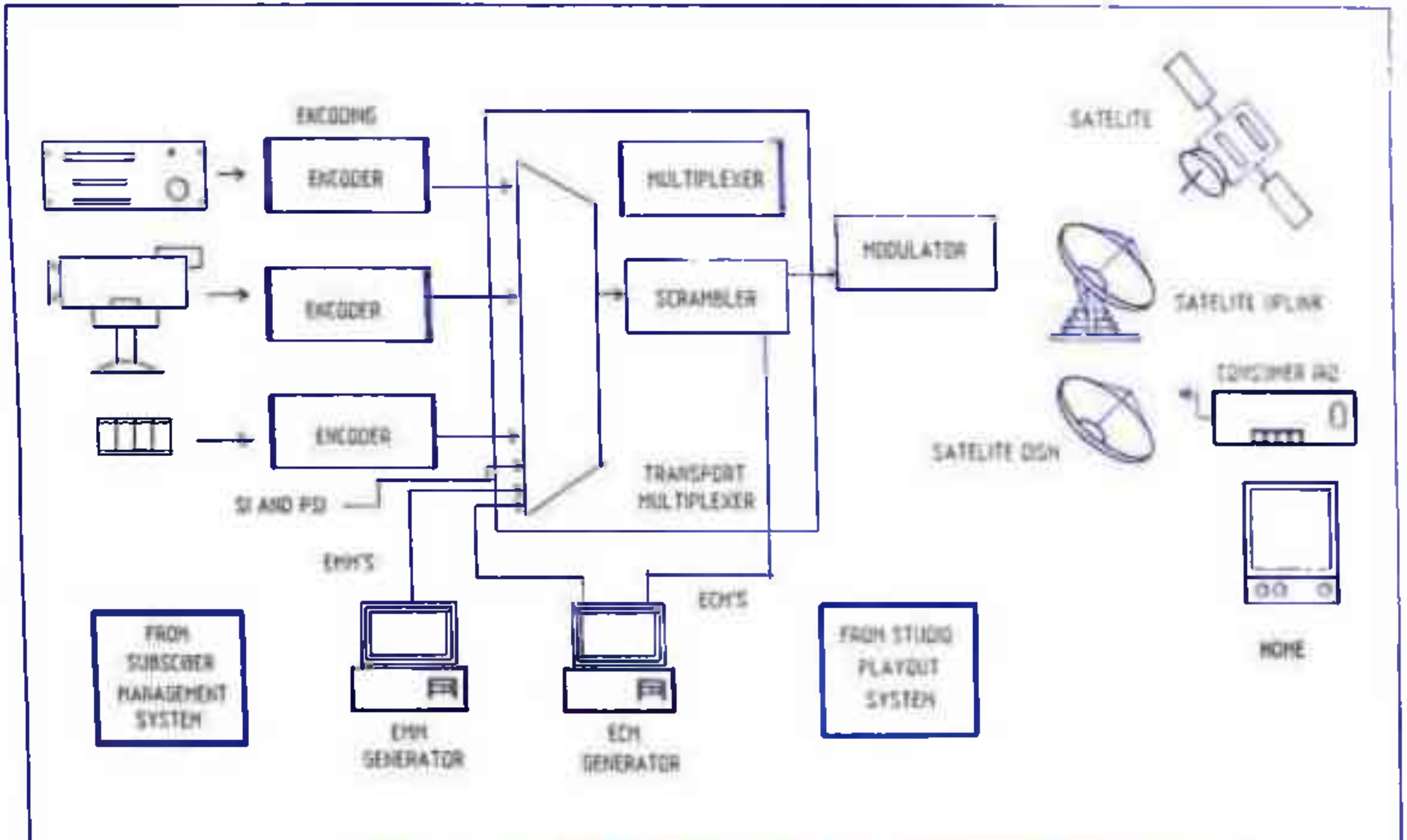


FIG. 1·12 TYPICAL DIRECT TO HOME SERVICE USING DSS be compatible with existing analog AM and FM radios and require consumers to purchase new radios to enjoy this new broadcast service.

1.3.3 New Services

A host of new services are being experimented and planned in the coming years. Few of these are being described.

1.3.3.1 Multimedia Broadcast Services

Multimedia system combines various information sources such as text, voice audio, video, graphics and images. The potential applications are Distance learning [79], Multimedia mailing system [80], Collaborative work system [81], Multimedia communication system [82], Information and demand system [83] and Multimedia Broadcasting [84]. Multimedia broadcasting is defined as a suite of interactive digital services which combine to provide high quality, multi-channel, mobile reception. This is capable of providing digital audio, video, 3D TV, data, Near Video On Demand (NVOD), computer software delivery , multi - channel transmission, pay per view, value added Services viz. RDS (Radio Data System), paging. tele-music, tele-shopping, teletext etc. The multi-media broadcasting is based on the concept that the digital coding of audio, video and other signal results in a data stream. As such after digital conversion, the difference between audio, video and computer data ceases to exist. It is in this context that multimedia broadcasting assumes significance. Once the channel is digitized, more and more services including audio, video, voice, graphics, animation, computer data etc. can be multiplexed [85] and put on a common delivery system which could be a fibre optic cable, terrestrial broadcast transmitter or a satellite in a Ku / Ka band capable of delivering signal directly to home using a 50 cm dish antenna. The system concept for a multimedia broadcasting is given in Fig. 1.13.

1.3.3.2 Integrated Services Digital Broadcasting (ISDB)

Throughout the world, the trend is towards an Integrated Services Digital Broadcasting (ISDB). In ISDB, analogue video, audio and test signals are digitized and these data alongwith other digital data for control and value added services are formed into a Transport Stream (TS) using fixed length packets. The conditional access is provided by multiplexing control signals into the data stream[86]. It is used to address various services to each subscriber or to target programmes to a specific group / customer [87,88]. This leads to virtual channel for pay per view or video on demand. The scrambling and encryption are provided using hardware embedded micro-processors or external smart cards. The digital video signal contains unused space during the line blanking period and carries no useful information. It is possible to insert compressed data into the video signal into these spaces. There is a maximum capacity of insertion of 270 megabit/s serial digital data stream which can carry 8 stereo pairs of 3.072 Mbit/s (AES/EBU standard AES-1992) or 16 audio channels or equivalent computer data. This data can be a software code, graphics, still picture or any other value added service.

The distribution of compressed signals without generation losses requires a broadband distribution network capable of interfacing with other video / computer

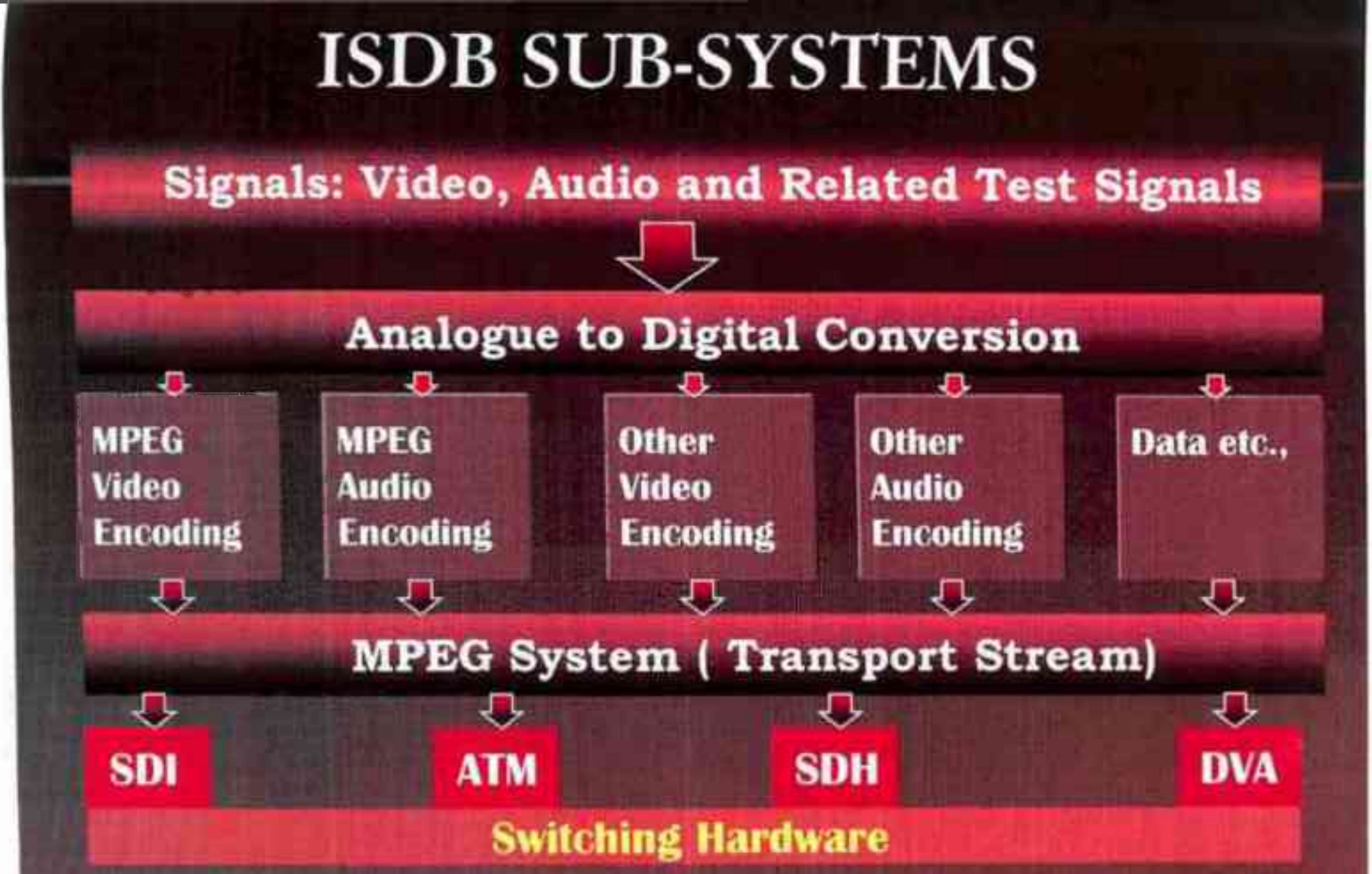


Fig. 1.13 ISDB Sub - Systems

/ telecommunication equipment. A server with disk arrays (RAID), computer network and SCSI interfaces is used to store/ archive / forward compressed data. This server is the central hub for transmission, non-linear editing, connecting to central database / Ethernet / WAN etc. (Fig. 1.14). The packet multiplex system provides easy inter-connection to open networks viz. Serial Data Interface (SDI) [89] which is the CCIR 656 worldwide standard for serial digital video, Synchronous Digital Hierarchy (SDH) (Telecom method for multimedia MPEG2 transport stream)[90], Asynchronous Transfer Mode (ATM)[91], satellite or terrestrial transmitters. An interactive link through a telephone or a wireless system allows putting questions to the speaker from the comforts of a drawing room.

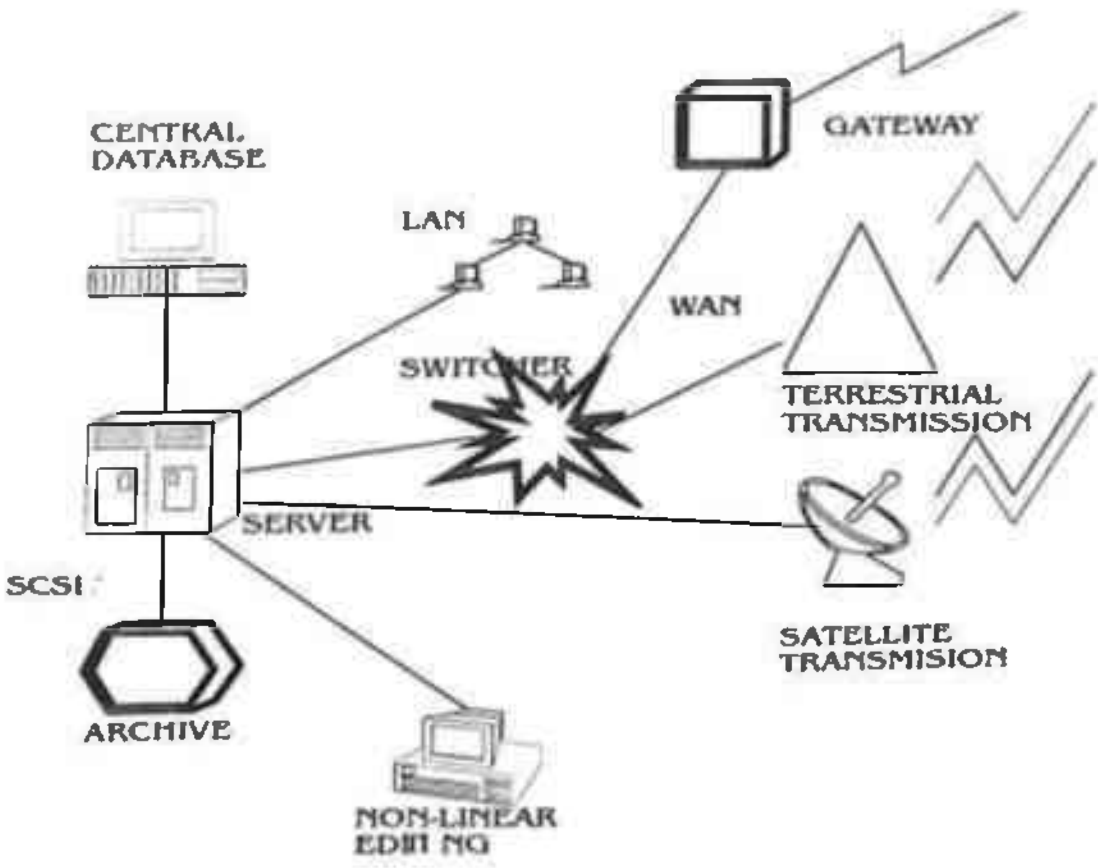


Fig. 1.14 ISDB Distribution System

1.3.3.3 Video On Demand (VOD)

The VOD is a service where user selects the kind of video and the time of its viewing using a remote control [92, 93, 94, 95]. Depending on the level of interactivity that the user enjoys, the VOD system (VODS) categorization is given in Table 1.10

Table 1.10

Interactive VOD (I-VOD)	The user has full virtual VCR capabilities, including fast forward, reverse, freeze and so on.
Staggered VOD (S-VOD)	Movies with staggered start times allow individual viewer to choose their viewing time and even " pause and restart" their movies as they wish.
Near VOD (N-VOD)	In N-VOD, the user is a passive participant, and has no control over the session except in the matter of choosing the programme.
Fully Interactive VOD	Fully interactive VOD service is based on Video Server. Multimedia is placed on this server. The Retrieval is done by the subscriber themselves [96].

1.3.3.4 Value Added Services

The mosaics of digital sound and TV broadcasting also contain data or value added services. The worlds of audio, video and data are rapidly converging.

Digital sound and video signals may be considered as an anonymous data streams. The efforts are on-going to include one or more digital data channels along with the broadcast signals. These data channels can be used for various value added services. For example Video and Data Services can be used to obtain personal responses from television viewers and for use in conducting educational programming, conducting polls, down-loading data, and ordering pay-per-view programming, services and products. There is a demand for transparent networks using different ways of transmission via terrestrial transmitters, satellite and cable with open interfaces to the various services. Digital audio broadcasting (DAB) and digital video broadcasting (DVB) are becoming digital integrated broadcasting (DIB) [97]. Broadcasters are attempting to reach standards and implement a system under the name Radio Broadcast Data Services.

1.3.3.4.1 Radio Data Services (RDS)

RDS system was introduced in 1984 to provide traffic information service for motorists in Germany [98,99]. RDS uses a free space in the stereo multiplex signal at 57 kHz for a 1187.5 bit per second wide data channel. The basic idea of RDS is to provide additional information for mobile reception. It can tell a receiver how to tune a station by format or call letters. Interactive Paging is one of the popular service of the RDS[100]. Today, RDS has been adopted in almost all European countries and also US, Japan and India.

Radio data are transmitted in the form of a continuous, binary data stream with 1.1875 Kbit per second. In selecting the modulation carrier and type of modulation for the RDS signals, the existing occupancy in the stereo multiplex baseband has to be considered. Fig.1.15 shows the audio mid band signal (15 kHz), the stereo pilot tone (19 kHz), the sideband signal 23 to 53 kHz and the signal with station identification, area identification and an announcement identification. The RDS signal is superimposed on this signal. Principle of RDS data stream processing is shown in Fig. 1.16.

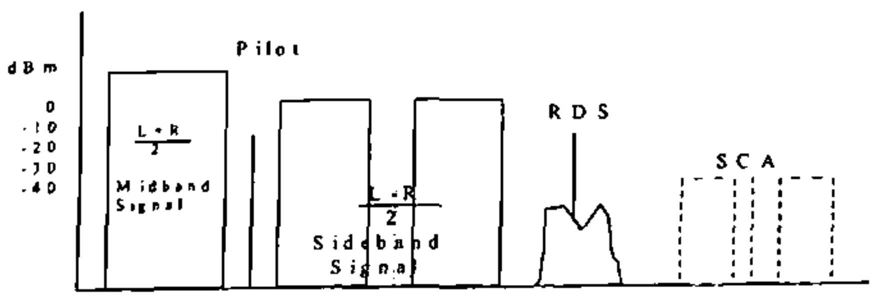


Fig.1.15 Stereo multiplex baseband with RDS & SCA (subsidiary channel authorization)

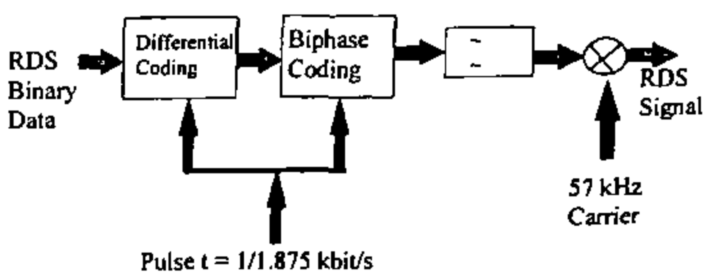


Fig.1.16 Principle of RDS data stream processing

1.3.3.4.2 Data Radio Channel (DARC)

ITU-RA (International Telecommunication Union - Radio Communication Assembly) approved the DARC system on October 1995 for large capacity FM *multiplex broadcasting to stationary and mobile receivers [101]. The* DARC system, developed by NHK (Japan Broadcasting Corporation) in March 1996., can provide a variety of data services for mobile receivers [102]. The system is used for providing traffic information, news, weather forecast and information services along with the conventional FM programmes. The system can also be applied to DGPS (Differential Global Positioning System) and Radio Paging services.

The DARC system uses a specially developed modulation scheme called LMSK (Level Controlled Minimum Shift Keying) which maintains transmission quality and ensures compatibility with stereo sound signals as well as RDS by controlling the injection level in proportion to the stereo L-R signals. DARC uses the product code of the (272,190) shortened difference set cyclic code that can be decoded rather simply by using a logic circuit, and gives greater robustness in adverse environments. *The data rate is 16 kbps.*

1.3.3.4.3 Teletext

The teletext service was introduced in Germany in 1970. Teletext is a service where digitally coded information is transmitted during the vertical blanking interval of the analog video signal, on one or more of of lines 10 through 21 of field 1 and the corresponding lines of field 2. The transmission bit rate is 5,727,272 bps, which is 8/5 of the colour subcarrier frequency. The standard for teletext service was issued by U.S. in March 1984 [103]. An encoder is used for inserting digital data and the text is transmitted along with the TV signal [104]. At the receiving end, a decoder helps in recovering the digital data and displaying the text on the conventional TV receiver [105]. The service suffers from the limitation of low data rate of the digital signal [106].

1.3.3.5 Information Superhighway

Information Superhighway is that ultimate communication network which will prove pervasive connectivity and sufficient bandwidth to allow digital media convergence and interactivity. With its growing ease of use and burgeoning popularity, the internet is fast becoming the all purpose information superhighway [107]. The predominant technologies for broadcasting on the Internet, use buffering, codec (compression/decompression) and streaming. Buffering is provided to make up for transmission delays. By allocating portion of memory to store a few packets, usually a dozen or so of audio/video information, the player always finds data to play from buffer rather than waiting for receipt of data from server. Codec technologies compress the data using compression algorithms at the server end and then decompress at the receiving end. Stream technology allows for real time repositioning within a file as well playing files as they are downloaded. The main services using Internet are described below.

1.3.3.5.1 Audio On The Net

Until the advent of several lossy compression technique, large size of audio files coupled with the bandwidth limitations of the Internet made it impossible to use the World Wide Web for efficiently and reliably accessing large volumes of archived audio content. This was because an entire audio file had to be downloaded to the machine before the playback could begin. Buffering, codec and stream technologies have made it possible to deliver sounds on the web even using 14.4 Kbps modem in a real time with controls for rewind, forward, pause and playback. The use of audio stream (continuous-delivery) technology permits playing of a single audio packet on receipt. The transfer communication being bidirectional, the player can request the server to send a specific audio packet [108].

Streaming audio technologies are designed to overcome the limited bandwidth of Web: a 14.4/28.8 kbps modem or 128 kbps ISDN connection. A 14.4. kbps modem has a throughput capacity of 1.8 kilobytes/sec, as against the requirement of 176 kilobytes/sec of CD quality audio (97 times the capacity of 14.4 kbps modem). For this reason all the streaming audio technologies compress the data drastically to match the throughput of the Internet connection. While CD quality audio requires a compression of 97:1, several audio codecs start with lower quality for example 8 kHz, 16 bit audio requires a compression of only 8:1.

1.3.3.5.2 Video On The Net

As a medium, video is much more demanding than audio, both technically and aesthetically. Compressing television quality video, whose original bandwidth is about 27 megabytes per second, to a usable 28.8 kbps modem, requires an astounding 7500:1 compression ratio. This extreme compression, achievable only by lossy techniques, causes tremendous distortion in the form of pixelation, blockiness and gross artifacts. Using a 64 Kbps -single line ISDN or 128 Kbps - dual line ISDN, greatly enhances the quality of the video. A high bandwidth network or T-1 connection can play a stored file at full frame rate [109].

1.3.3.5.4 Music Archives on Web

Web has opened exciting new possibilities for the music industry. Many recording artists, recording studios and record companies now operate their own webs. Already several radio stations have gone on line and are broadcasting programmes over the Web. University of Miami has experimented with the distribution of real time music concerts over the Web (http.// www. music miami, edu/music). Examples of other progressive Web sites include following:

http./Avww.realaudiocom/contentp/abc.html - American Broadcasting Corporation, USA.

http./Avww. sony. com - Sony Corporation, Japan

http.// www. bbcnc. org. uk - BBC, UK

http./Avww. msstate.edu/movies, - Internet Movie Database, Cardiff, UK

In the near future, Web connected fans could long on to hear their favorite musicians perform from the comfort of their own room [110].

1.3.3.5.5 Virtual radio

Virtual Radio is the non-stop user-definable music broadcast on the Internet that brings the latest in new music. Virtual Radio gives a wide variety of choices: where one can choose and listen the song on-line or download it to machine. This is not a sample, this is a radio-quality broadcast of the entire cut many times right off the band master's DAT. Each "Cyber Tune" (a fancy name given to the music being broadcast on the net) page contains band information, a description of the music, and images of the band. Virtual Radio is the new way to be exposed to today's music. Many Broadcasting organizations viz. BBC (British Broadcasting Corporation), MRTV (Malaysia Radio and TV). ABC (American Broadcasting Corporation) etc. are producing the programme and broadcasting them. The beauty is that an individual can be a broadcaster by taking a web site on rent [111,112]. Two individuals have started " All India Internet Radio" in USA. A reconstructed picture of two web pages of "First Radio" and "Internet Multicasting Service" are shown in Fig. 1.17. and 1.18.

1.3.3.6 Interactive 3D TV network

A multimedia communication network which demonstrated the feasibility of 3D television transmission through satellite was demonstrated in ITVS (International Television Symposium) held at Montreux in 1995 (Fig. 1.19) [113]. The bit rate was 30 Mbps and the satellite was operated in the 20-30 GHz. Interactivity

Fig. 1.17 A Web page of an Internet broadcaster

Fig. 1.18 Internet Multicasting Service

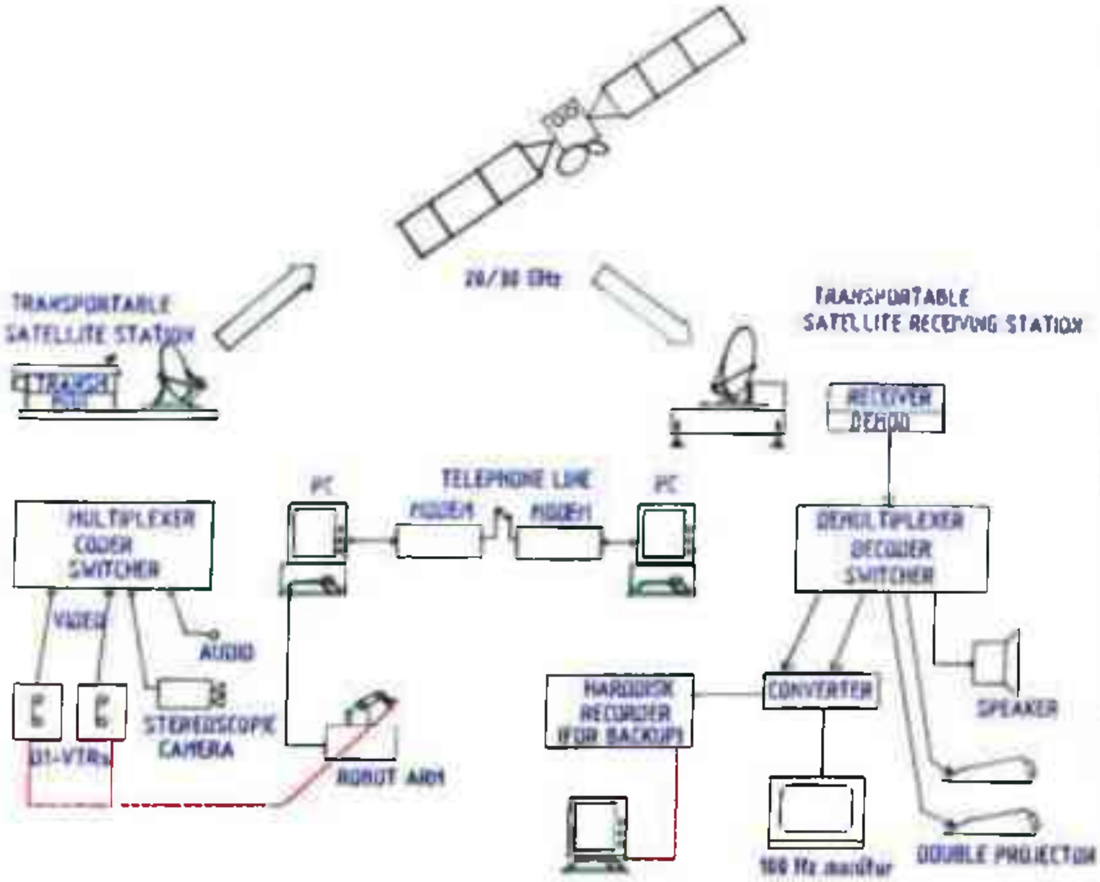


FIG.1·19 INTERACTIVE 3D TV EXPERIMENTAL SET UP was provided via a reverse feed modem allowing a robot arm in the Darmstadt studio to be controlled from the auditorium in Montreux. The demonstration was aimed to show the viability of a viewer controlled robot device via internet to select the programme or interact with the broadcast.

1.3.4 Receipt System

With the growing trend towards merger of broadcasting, communication and computers, the search for a receiver which can double as a computer and TV is ongoing. The development of digital interactive technology for domestic and personal use is arguably the phenomenon of the decade. Interactive television has been hyped and more recently disputed as the means by which digital services will be introduced to the home. An Individually addressable TV receiver with interactive channel guide has been developed [114]. Regardless of its title, Interactive Television is set to address the core issues which continue to face new media: how will the cultural and business success of conventional television be linked to the possibilities of digital networks and information technology (115). Future generation of television receiver would prove more than entertainment. It would pave the International Information Highway and build the common ground for communicating diverse high density, synchronous data. As digital video merges with the Internet, it can become the lingua franca of commerce, education, research and personal information. Few important R&D works are described here.

1.3.4.1 TVOT (Television of Tomorrow) Project

A TVOT (Television of Tomorrow) can be viewed as an extension of the Internet and the World Wide Web into entertainment or it could be viewed as an alternative model for television - Internet Video. This TVOT would be capable of decoding of sound and picture, understanding the formats, archival retrieval, and a work station for personal creative expression. With this view, a forum by the name, "TVOT" has been set up as an internationally funded research consortium to address worldwide digital television and media. Short term objective is to develop an open architecture television, and longer term goal is a three dimensional TV set.

1.3.4.2 National Interactive Communications Project

The National Information Infrastructure (NII) program is to provide consumers throughout the United States, with an in-home system for entertainment, education, business, and even shopping, using the widely publicized digital interactive communications system [116]. The focus of the study is on the viewing requirements, consumers needs, technical considerations for interoperability and scalability for a receiver set that can provide for HDTV viewing, computing and connecting to the information superhighway.

1.3.4.3 Receipt System for Audio / Video on Web

The receipt system consists of a Multimedia Personal Computer (MPC) with a sound card, a 14.4 Kbps modem or better connectivity, Direct SLIP or PPP connection to Internet alongwith Browser with media player registered as a helper application. The player offers features such as volume control, fast-forward, stop and resume. When a media link is clicked, the browser sends a request to a media server that returns a token file to the PC. This file requests the browser to spawn the appropriate player. Once the player is running, the player sends the request to the media server which transmits the data to the player. After few seconds of buffering, playback begins.

1.3.4.4 Demonstration at NAB 96

For years, analysts have said PCs won't succeed as a family entertainment devices until they exist in configuration that fit into the family entertainment center and double as a TV. Now systems aiming to achieve that marriage are on the anvil. In NAB 96, products have been released, which not only deliver PC staples such as application software, Internet access and CD ROM titles, but which also function as stand-alone TVs. An MPC3 (Multimedia PC) compliant, system can operate as an ordinary TV while the computer is of. The system can split the screen to display upto 12 TV channels simultaneously, or display a TV and PC image at the same time, by digitizing signals coming from cable or a VCR. It has video, computer and audio RCA input, and output jacks for integration into home theatre system. There's also a 125- channel cable ready TV tuner and a Broadcast Channel Lockout feature for parents to control children's viewing [117]. Several "ghost" canceling systems have been proposed to enable modified television receivers to cancel multiple reflected signals and improve picture quality [118,119].

1.3.4.5 Direct TV Link Up

Research is being carried out to provide video broadcasts and related interactive data services for personal computers using Digital Broadcast Satellite (DBS) System. *Users will be able* to *download large* files in seconds using the broadband delivery system. Microsoft plans to build support for TV reception directly into Windows 95. The Direct TV set-top box will basically be shrunk down to a card that will fit in the PC and enable users to watch the regular video channels, either on the PC or on a connected TV, but data services will be available only on the PC. The service will also provide multimedia magazines with downloadable interactive programs and other services targeted at home consumers, including sports scores. There may also be tie-ins between video programming and related data services [120]. The concepts for transmission and receipt of direct TV link up are shown in Fig. 1.20 and 1.21.

1.3.5 Future of broadcasting

It is an exciting age we live in and each day new technologies are developing to make broadcasting more efficient, cost effective or just easier to administer. The combination of MPEG digital data compression and broadband fiber optic cable networking raises the prospect of almost limitless number of fast communication channels between broadcasters and consumers. Distinctions between broadcasting and narrowcasting (selective targetting of individual users or a small user group) *will dissolve within a loose three* tier structure of satellite based delivery system , terrestrial broadcasting and local- cum-minority interest fiber

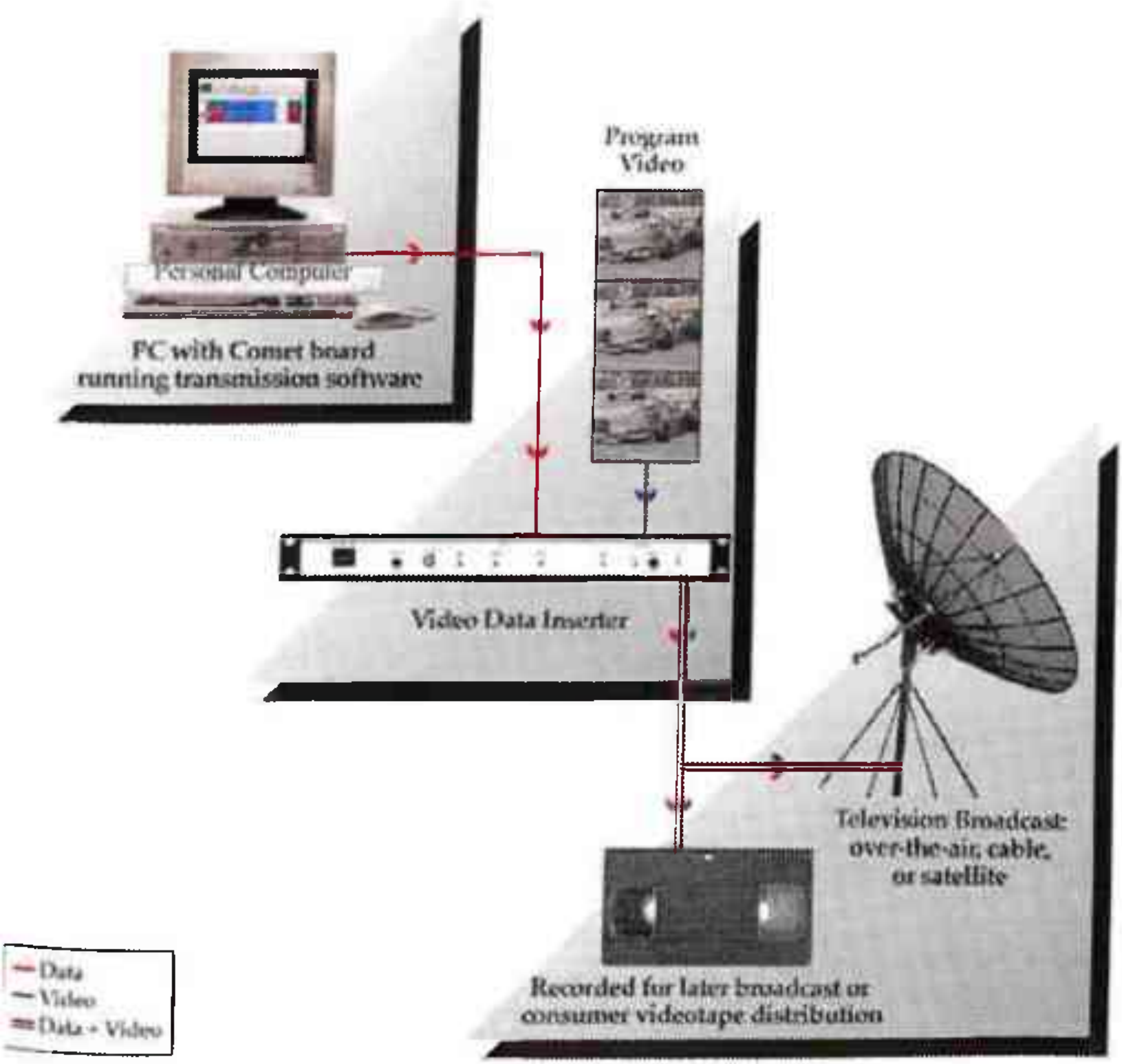


Fig. 1.20 Broadcasting multimedia data

Fig. 1.21 Receiving Multimedia data

optic cable As 20th century gives way to the 21st, much broader range of programme will have to be delivered to cater to so many channels. The studios will go digital with non-linear disk based editing allowing crystal clear production of TV programmes. The virtual studio shall let broadcasters turn almost any room into a very usable television studio. Digital technology in the Broadcast Satellite applications shall allow small dishes to be used for receiving limitless channels. Multi-lingual broadcasts shall allow an individual to see a programme in his own language [121]. Electronic Programme Guide (EPG) shall be a common feature [122]. Interactive broadcasts through cyberspace shall allow users to define their own channels. Simultaneous viewing of the Internet pages and TV programmes shall be possible [123]. And tomorrow holds even more for us to see.

1.4 Objective of the Present Research

Information System plays an important role in providing new forms of customer service, new distribution channels, rearranging organization boundaries, redesigning business processes and enabling enterprises to achieve economies of scale[124,125,126,127,128,129,130]. As such, an effective information system is a key to sound administration and operation of the broadcast archives in the emerging global scenario described earlier. The objective of the present research, therefore, is to develop a model for Information System for broadcast archives in the context of emerging Information Superhighway. This means that the future archives must be able to cater to the needs of Information Society where an individual has some control to choose the content for viewing / listening at his own choice of timing. In this thesis the model developed to cater to the needs of such an Information Society is presented.

1.4.1 Archives in Broadcasting

As per Webester's Encyclopedic Unabridged dictionary, "the archive is an extensive record or collection of data". In the context of broadcasting, an archive consists of audio and video programmes stored on tapes/disks, details of contents in the text form, where applicable, and it's catalogue. The programmes consist of music, talk, drama, film, animation, etc. The objective of broadcasting is to educate, inform and entertain masses. Therefore these recordings pertain to variety of subjects like health, hygiene, medicine, education, entertainment, etc. These programmes are of great cultural and historical value and reflect the nation's evolutionary development besides depicting country's changing culture, ethics and living style. Therefore, they need to be preserved for a long time.

Traditionally, these programmes are stored in analog form on magnetic tapes, disks and films. The films have been gradually replaced by video tapes. The broadcast centres are spread throughout the country and as such the archives are scattered and every field unit (Radio /TV centre) has an archive attached to it. The material available in the archives is required to be referenced for production of new programmes. They are required by units other than their place of storage but the only method available at present is to duplicate the material and send the tape by post.

With the advent of satellite based broadcasting, cable TV is becoming very popular. The Direct-To-Home services are also on the horizon. These transmissions have crossed the geographical and regional boundaries and the effort of all the broadcasters, world-over, has been to provide its service to different parts of the globe. This trend is evident from availability of a number of channels in India in the form of broadcasts from BBC, Star TV, Zee TV, El TV, etc. The popularity of these channels are evident from the facts that there are now 15 million CATV connections against 55 million TV receivers in India [131]. Recently, Star TV has launched a Hindi Channel. Zee and El TV with their Hindi Channels are already quite popular. Few other channels doing regional programmes are also able to attract higher viewership. All these channels need more programmes which can not be produced at short notices. Therefore, they have to depend upon the available archives.

This trend has made the archives available in any country, especially with All India Radio and TV India, very precious and valuable. India is a country of rich cultural heritage and is endowed with great traditions in almost every walk of life. Classical and folk music has been an integral part of this heritage. AIR and TV India, as the only broadcast organizations in the country, have the unique privilege of acquiring about 100,000 recordings pertaining to great Indian personalities as well as recordings of various phases of social transformation undergone by the country during independence struggle and in the post independence era. The archival activities started in April 1954, with the transfer of about 7000 presto-discs to tapes. All programmes broadcast now form a part of the archives. The sound recordings in the archives are preserved on ¼" analog tapes (1.5 mil mylar) and on gramophone discs. The video recordings are in various formats like D-1, D-2, D-3, D-5, DCT, Betacam and DVC. All these storage conform to the internationally accepted standards. The material has been categorised under various heads like music programmes, spoken words, sound effects, etc. Further sub-classification viz., light music, devotional songs, gazals, opera music, haveli music, etc. has also been done under the category music, for easy access and retrieval.

With the passage of time, the quality of a number of holdings has degraded because of the inherent limitations of the storage medium. The information system is also based on a mix of cardex cum computer system. Presently, the archival collection is available for programme production and reference to AIR/ TV India only. Thus, there is a need to preserve the holdings in archives and also harness them commercially.

1.4.2 Scope of the Present Work

The key functions of a broadcast archives are: Creation and Capture, Storage and Management, Distribution, Search and Access, and Rights Management. These functions are shown in Fig. 1.22. The core depicts the primary functions of storage and management while the outer rings represent the subsequent functions. The scope of the present research work is to develop an Information system comprising all aspects of the archival material, keeping in view the technological trends towards Integrated System Digital Broadcasting (ISDB),

Fig. 1.22 Key functions of an Archive

Direct Digital to Home (DTH), Information Super Highway and interactive systems for Multimedia Broadcasting. The model is developed keeping in view the latest and emerging technology in the field of broadcasting, computers and communications.

Chapter 2

Broadcast Archives - the Present Status and the problems

2.1 Broadcast Archives

Broadcast organizations all over the world have been storing important programmes for a long time. Traditional broadcast archives, also called as resource centres, collect and store tapes and disks, cataloged so that the broadcast material can be found and retrieved easily. These cataloged materials are called holdings. After a holding is acquired, cataloged, and added to a collection, it is made available to authorized users. Measures are put in place to preserve and protect the holdings.

Broadcast archives contain a variety of holdings: video, audio, text, images, (album) and so on. These holdings have different values, origins, and life. It encompasses material acquisition, storage, management of information, intellectual property rights management, search and access, and distribution technologies into a single library architecture. The current users of the archives are programme producers who use these holdings to rebroadcast the programmes and produce new programmes. Archives serving broadcast organizations have different requirements than libraries that serve 200 film editors in a movie studio, or libraries that provide business information to commercial customers. A new dimension is that with the on-set of interactive broadcasting, the listeners / viewers will also become the users of the archives.

Before we further discuss the broadcast archives, terminology used in broadcast archives is discussed below:

2.1.1 Terminology

The following terms are defined for this thesis:

2.1.1.1 Collection

A collection is an aggregate of holdings, gathered together because of one or more shared attributes. These are also called a folder in some implementations. A 'film song based programme - "Chitrahar" is a collection.

2.1.1.2 Content

Content refers to the information of album, such as a picture, the text of a document, the video / audio of a song and so on.

2.1.1.3 Holding

A holding is an individual intellectual property that may consist of one or more parts. The holding includes its parts, rules about access and usage, and searchable attributes that apply to the holding and its parts. Attributes include information kept in the catalog, as well as the actual content of the holding. A holding is the smallest cataloged unit in the archive. A speech or a drama is a holding. A holding is referred to as an item.

2.1.1.4 Clip

A clip is a unit of intellectual property contained within a holding, and independently presented. For example, a film is a holding that contains songs, which may be a separate intellectual property with its own license agreement covering access, use and compensation. A clip is accessed only through the holding of which it is a part. However, certain new methods allow direct access of the clips.

2.1.1.5 Metadata

Words that describe the properties of an object (i.e. Recording date, singer's name, number of bytes in a film).

2.1.2 Functions of Broadcast Archives

The main functions of a broadcast archives are: Creation & Capture, Storage & Management, Distribution, Search & Access, and Rights Management (Fig. 2.1). These are described in following sections.

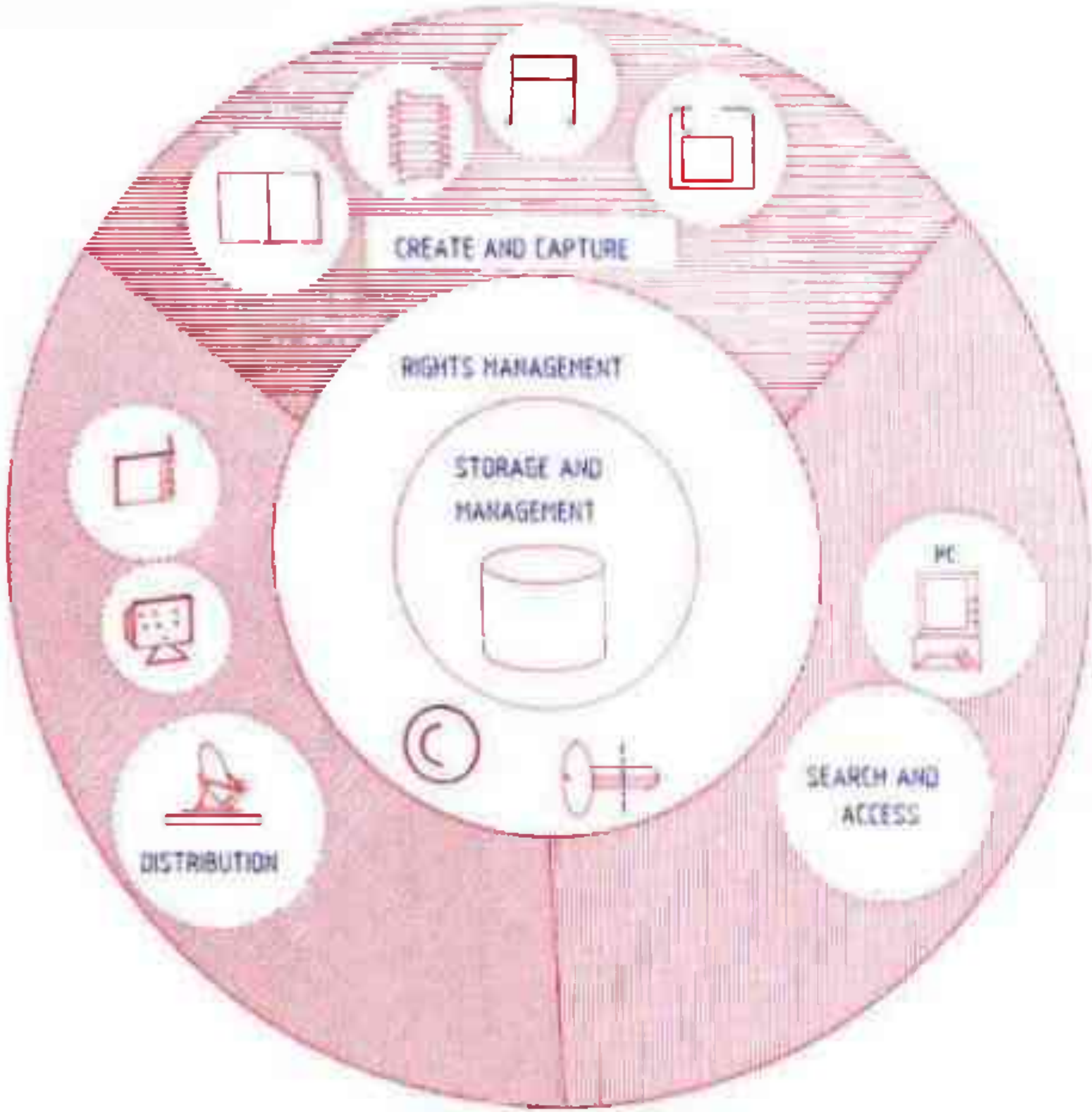


FIG. 2.1 SCOPE OF A BROADCAST ARCHIVE

2.1.2.1 Creation and capture

The material in form of the scripts, album, audio and video tapes etc. are created at various programme production centres located at different parts of the country. The materials are generally received by the archives after broadcasts. These objects are created in analog formats albeit in coming times, digital forms may be used in the creation process. Most of the existing multimedia information needs to be digitized. This complex process of capturing "knowledge" requires careful analysis and preparation. However, the most important function of the archive is to collect the material in what so-ever format it may be available and then store it in an appropriate format.

2.1.2.2 Storage and Management

The holdings are valuable assets of the creators, and of the archives who make the holdings available to others. Multimedia information has long-term value. Many recordings become part of the cultural heritage, which are to be preserved for generations to come. Scientific data needs to be preserved for many years, etc. The archives are responsible to ensure their integrity and physical protection. This means that the archives must function under trusted administrators in secure locations.

In an archive, the smallest cataloged unit is the holding. A holding has a unique identifier that is used to retrieve the materials from the archive. Holdings can be more than one physical information object, or part. For example, a song sequence programme like "Chitrahar" is a holding for cataloging and distribution purposes, but each song is a separate part of the holding that can be separately presented. Each part may be governed by a different set of presentation, permissions, and compensation rules.

A part is usually a single unit. Some parts, however, can be stored as many different renderings. A part is the smallest independently stored and presented information object.

For archives, the holding is the unit used to link together the different parts of one intellectual property, as well as all the information needed to present them, and the rules for managing their rights and permissions.

2.1.2.3 Distribution

The potential users of the archival holdings are producers who may be located at different geographical locations. The holdings are finally meant for the viewers / listeners. The distribution path to the viewers /listeners in broadcast archive is via the broadcast network. With the interactivity being the buzz word in the future broadcast systems, archive should ideally be capable of providing access to all the data, to anybody, from anywhere at any time through any existing computer network like the Internet or other private networks.

The electronic distribution of large objects requires large bandwidth network not usually available in many existing networks. Broadcast networks don't provide return path. While most business data can easily be transmitted over current phone lines, new technologies are required for large multimedia objects, e.g., fiber optics, Asynchronous Transfer Mode (ATM) switches, network management software, etc. The flexibility to locate the object servers close to the users can also provide better performance.

2.1.2.4 Search and Access

Traditionally, the details of the programmes are indexed tapewise and retrieved on demand from programme production centers, by physically scanning the index cards. In a large broadcast organisations with programme production centers spread over a number of locations, the inconvenience and delay in retrieving the desired information and content results in sub-standard programme production. The problem becomes quite acute when the retrieval is required within a very short time span. With the introduction of computers in various fields of broadcasting, many organizations have started using computers for search and retrieval.

2.1.2.5 Rights Management

Rights management means that national and international laws relating to intellectual property, such as copyrights, patents, and trademarks are followed. Rights management also applies to contractual obligations between content owners and broadcasters because many programmes and films are owned by the private producers and broadcasters have to pay a royalty for every use.

But, rights management is not only about protecting holdings and compensating owners. Equally important is protecting viewers/listeners from counterfeit or corrupted material. For example, the broadcaster is concerned about the relay of a film that has not been screened by the censor board or subjected to peer review. One way that broadcasters exercise control over the use of their property is through license agreements and compensation rules. The rights and royalties agreements that apply when an intellectual property is transferred from the source archive to one or more regional archives are different from the rights and royalties that apply when the multimedia data is put to broadcast. An example is the licensing of a film by a producer to a cable TV company. The licensing and billing policies that apply between the producer and the cable company are quite different from the licensing and billing policies that apply between the cable company and the subscriber.

2.2 Present systems of broadcast archives management

The present system of archives management in broadcast organizations is described below:

2.2.1 Acquisition System

In broadcast organizations, there are a pool of producers responsible for different type of programmes viz. Drama, Serial, Skit, News etc. These producers generate new programmes by shooting events and thereafter dubbing it by mixing effects, scenes, animation etc. The producers also depend upon outside agencies for programmes and films. All these programmes and films become a part of archive. A copy of tape is acquired for the archives from field units for locally produced programmes. Depending upon the contract, the royalty may have to be paid to the outside producers for every broadcasts.

2.2.2 Delivery System

The present system of delivery consists of duplicating of the tape on conventional tape recorders and then sending them through postal channels. As for as listeners /viewers are concerned, hitherto the mode of delivery is analog broadcast transmitters in the terrestrial mode. Recently with the introduction of DBS services, the delivery is also through satellite. The listeners /viewers have *no control* on the content and the timings, albeit a number of interactive services are being planned. One such service is TPS (Television Par Satellite) of France which is proposed to launch an experimental service in 1997 on Eutelsat Hot Bird-4 and regular service from 1998/99 from Hot Bird-5. The service using MPEG-2 shall provide VOD (Video On Demand), PPV (Pay Per View), Tele-shopping etc. [132]. Many organizations have also started duplicating these programmes in the CD format for direct sale to the individuals/ resellers.

2.2.3 Storage System

The present storage system is on magnetic disks or tapes. While audio is in analog format, the video storage is in various formats. The most popular formats are described below.

2.2.3.1 D-1

This format uses 19 mm tape and allows upto 94 minutes of recording on one cassette. This is based on the recommendation ITU-R BT.601, usually referred to as 4:2:2. It uses a sampling rate of 13.5 MHz for luminance and 6.75 MHz for the two colour difference signals. This sampling standard was evolved by a joint SMPTE/EBU task force which was set up with an aim to introduce the compatibility between 625/50 and 525/59.94. The Task Force examined luminance sampling frequencies from 12 MHz to 14.3 MHz and selected 13.5 MHz as a common sampling frequency for both 525 and 625 line system.

The choice of sampling frequencies gives 720 samples / active line for luminance and 360 samples for colour differences and also includes space for representing analogue blanking within the active line. The equivalent analogue bandwidths are 5.75 MHz for luminance and 2.75 MHz for colour differences. Quantisation was initially based on 8 bits giving 256 equally spaced levels; luminance is encoded on 220 levels and each colour difference on 224 levels to reduce the bandwidth requirements.

2.2.3.2 D-2

This is a composite (PAL or NTSC) format which allows recording of upto 208 minutes on a single 19 mm cassette. The composite encoded signal is one channel of 6 MHz or less.

2.2.3.3 D-3

This is a composite (PAL or NTSC) format using 12.5 mm tape allowing upto 245 minutes of recording on a single tape.

2.2.3.4 D-4

Non-Existent

2.2.3.5 D-5

This is the component format with CCIR 601 sampling at 10 bit resolution using 12.5 mm tape.

2.2.3.6 DCT (Digital Component Technology)

This is component format using 19 mm tape and approximately 2:1 compression

2.2.3.7 Digital Betacam

This is component format using 12.5 mm tape and approximately 2:1 compression. The Betacam format was introduced for ENG (Electronic News Gathering). It uses 5.5 MHz bandwidth for luminance and 2 MHz for colour difference signals.

2.2.3.8 Digital Video Cassette (DVC)

This format was developed for the consumer market by a consortium of manufacturers. It employs 6.25 mm wide tape to record 525/60, 625/50 and HDTV. Digital intra field DCT compression (about 5:1) is used to record 13.5 MHz, 8 bit, 4:1:1 (525/60) or 4:2:0 (625/50) video plus two 16 bit / 48 or 44.1 kHz audio channels on to a 4.5 hour standard cassette (14.6 x 78 x 125 mm) or smaller 1 hour casstte (12.5 x 48 x 66 mm). The video recording rate is 25 Mbit/s.

2.2.3.9 DVC Pro

This is a derivative of DVC and is intended for ENG applications. It uses 5:1 compression, double the tape speed to allow wider video tracking. It also allows quick downloading of the news to a video server/ non-linear editing system with it's 4X playback.

2.2.3.10 Films

Feature films are also available on 35 mm film. However, these are generally being phased out to video tapes. With the finalisation of DVD MPEG-2 standard, the films are also being made available on DVD.

2.2.4 Information System

Information System is vital for the search and access, rights management etc. of holdings. The earlier system had been to categorize the material into various classes and subclasses using the Dewey numbering system. With the availability of computers, Data Base Management System (DBMS) is being extensively used now-a-days, in many broadcast organizations for archives. The DBMS allows storage of data in a computer and its retrieval at any time by any authorized user. The need for immediate information for semi-structured and unstructured decisions encourages the use of Data Base Management System (DBMS) as a tool for information management.

Over the past twenty-five years, computers, more than any other innovation, can be credited with bringing about tremendous improvement in the performance of an organization's operational, tactical and strategic activities [133]. It was about

25 years ago that DBMS began to appear, running on bulky computers. During the intervening years, data-base technology has been at the heart of many trends in computing viz. decision support system, engineering and manufacturing control, real-time transaction processing etc. Broadcast organizations started using the technology in the field of archives in the late 80's [134].

2.2.4.1 Database Concept

DBMS is a computer based system that accesses integrated data that crosses operational, functional or organisational boundaries within an enterprise. (Fig. 2.2). *According to James Martin "A collection of data designed to be used by* different programmers is called a database. It is a collection of interrelated data stored together with controlled redundancy to serve one or more applications in an optimal fashion; the data are stored so that they are independent of programs which use the data; a common and controlled approach is used in adding new data and modifying and retrieving existing data within the database. "[135].

As Such, Data base:

- is a repository for stored data,
- is a collection of related data about an enterprise with multiple uses,

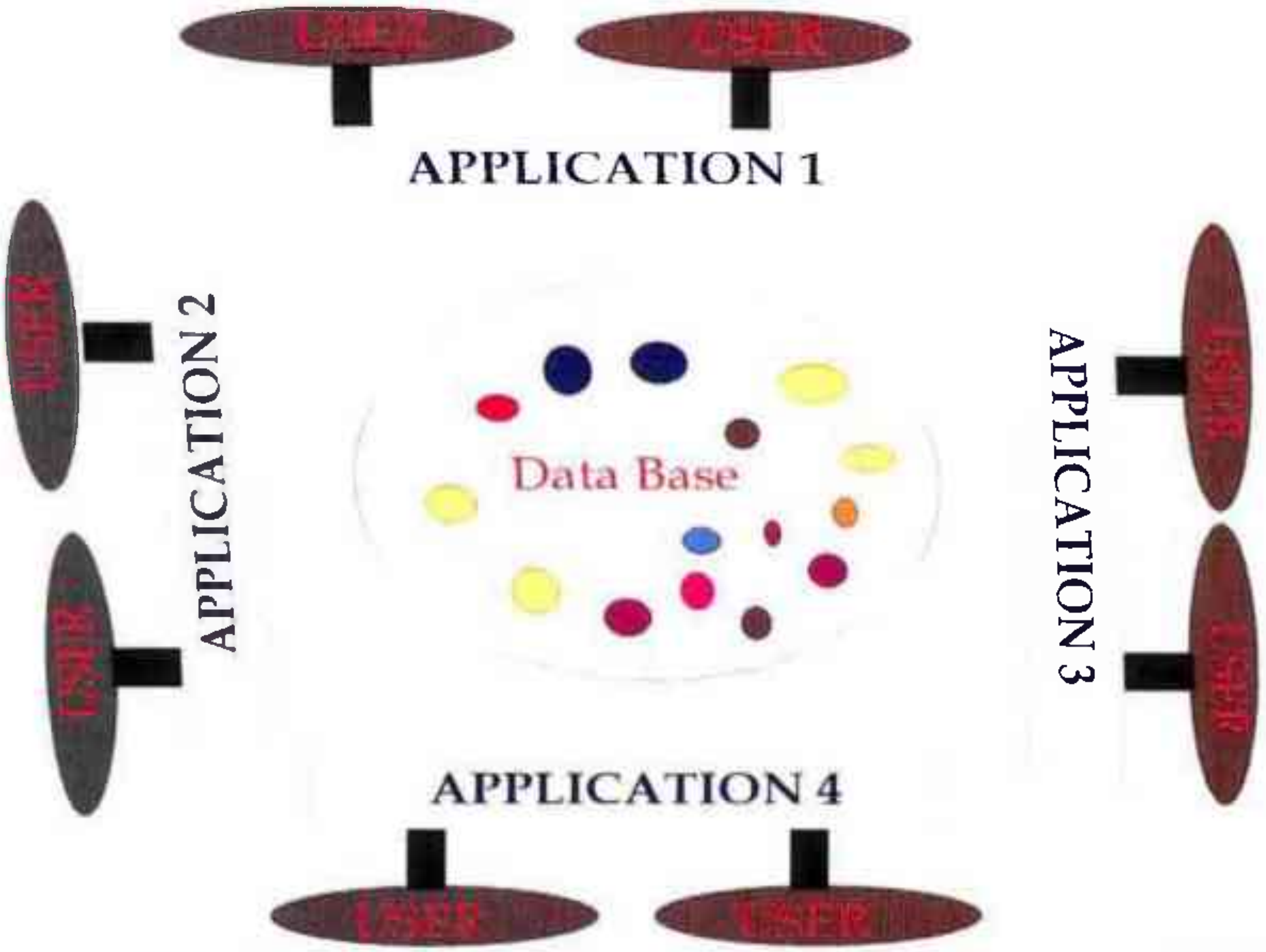


Fig 2.2 DATA BASE MANAGEMENT SYSTEM

- is used by many users,
- has a controlled redundancy.

2.2.4.2 Database Design

The system development life cycle (SDLC) embraces the process summarized in Table 2.1, in conjunction with the function design activities [136].

Table 2.1

Database Design Process

1. Requirement collection and Analysis
2. Conceptual Database design
3. Choice of a DBMS
4. Data model mapping (or logical Database design)
5. Physical Database design
6. Implementation

The stages involved are given below:

- Preparation of schema/entry forms

Schema is a logical data-base description. It gives the names of entities (fields) and attributes and specifies the relations among them.

- Data Entry

This consists of data entry in respect of each field.

- Output from data base

There are two types of output:

(i) Fixed reports (Structured)

(ii) Instant query (Unstructured)

The structured reports are generated through DML & 4G Tools. SQL (Special Query Language), QBF (Query By Form) etc. are used for Unstructured reports / instant query.

2.2.4.3 Selection of DBMS Package

The commercial arena has used three kinds of database management systems (hierarchical, network, relational). A new wave of object oriented database management system is now available which is becoming more attractive due to the richness of their data model in capturing data semantics [137]. Selection of a DBMS Package is done on the basis of considerations of development language, end-user language, data structure, flexibility, security, integrity, requirement of hardware, performance and efficiency, portability, vendor support, cost and future requirements.

2.2.4.4 System Development Approach

Traditional systems development methodologies attempt to control the process of building DBMS. They divide the system building processes into phases and stages. This division facilitates project status control and allows frequent reviews by both development and user management. Unfortunately, these methods are not effective in dealing with applications where requirements are not explicit initially or where there is high rate of change in the environment.

A well managed system development project that uses a traditional approach results in a system that strictly meets the requirement specification. Unfortunately, the specification often dose not contain the application's actual need because they change during the long development process.

In view of the above mentioned factors, a variety of new paradigm for system approach have been evolved viz. Prototyping [138], Heuristic Development [139], Infological Simulation [140], Middle Out Design [141], Evolutionary Design [142] etc. Many broadcast organizations have used a prototyping approach for development of Information System for archives. In prototyping, an intentionally incomplete system is quickly implemented and then evolved into final version through iterations of system usage and modifications. It can be defined as producing quickly built, purposely incomplete system. This approach promises order-of-magnitude reduction in time and effort.

2.3 Problems in the present system

The present system of archival management has a number of drawbacks in administering present day broadcasting. Few of them are listed below:

2.3.1 Impact of format changes on archives

The greatest danger caused by the video format changes is in the preservation of the material for the future. As formats multiply, the confidence in the viability of a magnetic record /tape as an archive diminishes. With the passage of time, the recorders using analog component or composite formats shall be phased out. It may simply become impossible to recover the archival material.

Digital recording offers archivists a medium in which image and sound don't deteriorate with time. However, there is multiplicity of formats in digital domain too. At NAB-96, Sony and Panasonic have come out with two new formats. These are Betacam SX (based on MPEG-2 4:2:2 profile at main level) and DVCPRO (4:1:1 component digital video with 5:1 intraframe compression [143]. These developments are adding to more confusion. It is essential that an agreed data format is evolved which could be used equally to archive information, books, sound, images and video. There should be a common delivery format for the computer and television industry which should also be economically attractive.

2.3.2 Deterioration in the quality of tape over a period of time

With the passage of time, the magnetic coatings on tapes get damaged or dropped. The disks also get scratches over a period of time due to accumulation of dust etc.

2.3.3 Loss in quality on successive dubbings

The quality of analog tape deteriorates after successive dubbings. With the change of formats, a dubbing in the new format has to be resorted. Table 2.2 shows the picture degradation in dB with successive dubbings.

2.3.4 Effectiveness of the Information System

The effectiveness of the Information system has been the subject of research for quite some time [144, 145, 146, 147]. The research is based on an information retrieval model [148]. In the model a user recognizes an information need. The

Table 2.2

Picture degradation of Analog tapes on successive dubbings

Generation	Picture degradation in dB
1	0
2	-3.0
3	-4.8
4	-6.0
5	-7.0
10	-10

user comes to the information system with a request based on that need. The retrieval system matches the request against representations of holdings in the archive. The task of the system is to present the user the information that may satisfy his need. The methods have been developed to define the relevance [149] and thus the effectiveness of the Information System. In the present system, the producers are reluctant to learn the 4G query languages for structured or semi-structured queries and define their requirements. Similarly for data entry and making queries, code books have to be consulted. This limits the effectiveness of the system [150].

2.3.5 Present System not suited to Interactive broadcasts

Broadcast technology is rapidly turning to digital format due to standardisation of MPEG-2 compression. The analog format is unsuitable for non-linear editing. The trend is moving towards interactive broadcasting viz. VOD, Cybercasting, etc. Unless the programmes are stored on-line in digital format, neither interactive on-demand broadcasting nor the use of techniques viz., virtual studios etc is possible. Similarly analog HDTV broadcast is not economically viable due to huge bandwidth requirements. Thus, the present analog system of storing the holdings in the archives is not suited for the changed requirements.

Chapter 3

Technology considerations for Future Archives

3.1 Enabling Technologies

In this chapter we shall examine the technological options, their suitability and finally the desirable technology for the future archives. The technological advances that shall affect the broadcast archives are described below.

3.1.1 Data Compression

High quality video compression is one of the Holy Grails of Multimedia Broadcast Services. Data compression techniques reduce the requirements of transmission bandwidth and the storage capabilities. A number of standards viz., JPEG[151], MPEG-1[152], RM8[153], MPEG-2 [154,155], H.320, H.261 [156] etc. have been developed. These standards define the rules governing the compression of still image, video and audio for storage or transmission. JPEG is used for still image compression. MPEG offers the best image quality per byte and is therefore ideal for low bit rate applications like video servers and CD-ROMs. MPEG-1 is used for audio/visual storage on compact disks (CD), while

MPEG-2 is aimed at higher end broadcast systems. H.320 standard of ITU -T is for video-conferencing systems over ISDN. Another ITU-T standard H.261 is used for the video compression part of a conferencing system. Incidentally ISDN (64 kb/s or 128 kb/s) using ISO/MPEG compression is being used for full duplex transmission of news [157]. There are several other proprietary compression algorithms in use [158,159,160,161].

3.1.1.1 Audio Compression

A stereo audio needs two analogue circuits each with a bandwidth of 25 kHz to distribute audio. A stereo CD transfers digital data at 1.411 Mbps (Table 3.1).

Table 3.1

Bit Rate for Stereo CD and Audio Bandwidth

Bit rate required for PCM = sampling frequency x length of digital word x no. of channels

= 44.1 Ksa/s x 16 x 2

= 1.411 Mbps

Audio Band width = 1/2 x sampling rate (Nyquist sampling theorem)

~= 25 kHz for each channel

Thus digital audio needs a bandwidth of 1.411 Mbits/s for stereo or 700 Kbits/s/channel. Taking into account additional bits required for channel coding, synchronization and error correction, a bandwidth of 1.5 MHz is required for distribution. Similarly 60 minutes stereo digital needs 630 MB of storage space. A number of coding algorithms make it possible to compress data without noticeable distortion[162]. These are given in Table 3.2 below:

Table 3.2

Algorithms for Audio Compression

Algorithm	Compression	Coding	Usage
AC-2	1/6	Transform Coding	Digital Audio Broadcasting (DAB), multi-channel entertainment quality satellite broadcasting to cable head-ends, Interstudio transmission, Digital studio to transmitter links (DSTL), Disk based storage and digital cart machines, ISDN
ATRAC (Adaptive Transform Acoustic Coding)	1/5	Hybrid Coding	Mini Disc (record and playback)
PASC/ISO/MPEG(1) (Precision Adaptive Subband Coding)	1/4	Subband Coding	Digital Compact Cassette (DCC), CD-I
MPEG/Audio[2]	1/4~1/12	Hybrid Coding	Distribution & Transmission of 15 kHz stereo at 192 kbit/s and 128 kbit/s.
AC-3	1/4	Modified DCT	High Definition Television (HDTV), Digital Video Disk

3.1.1.1.1 AC-3 Coding

AC-3 [163] coding technology has been adopted by the Advanced Television System Committee as the audio service standard for High Definition TV (HDTV). It has also found applications in consumer media (laserdisc, digital video disc) and direct satellite broadcast. The AC-3 encoder block diagram is shown in Fig. 3.1. Encoding is done in the frequency domain, using a 512 point MDCT (modified discrete cosine transform) with 50 % overlap. In the event of transient signals, improved performance is achieved by using a block-switching technique, in which two 256 point transforms are computed in place of the 512 point transform. A floating point conversion process breaks the transform coefficients into exponent / mantissa pairs. The mantissa are then quantised with a variable number of bits, based on a parametric bit allocation model [164].

The AC-3 bit allocation model uses principles of psychoacoustic masking to decide how many bits to provide for each mantissa in a given frequency band. Depending upon the extent of masking, some mantissa may receive few bits and some may receive no bits at all. This reduces the number of bits needed to represent the source.

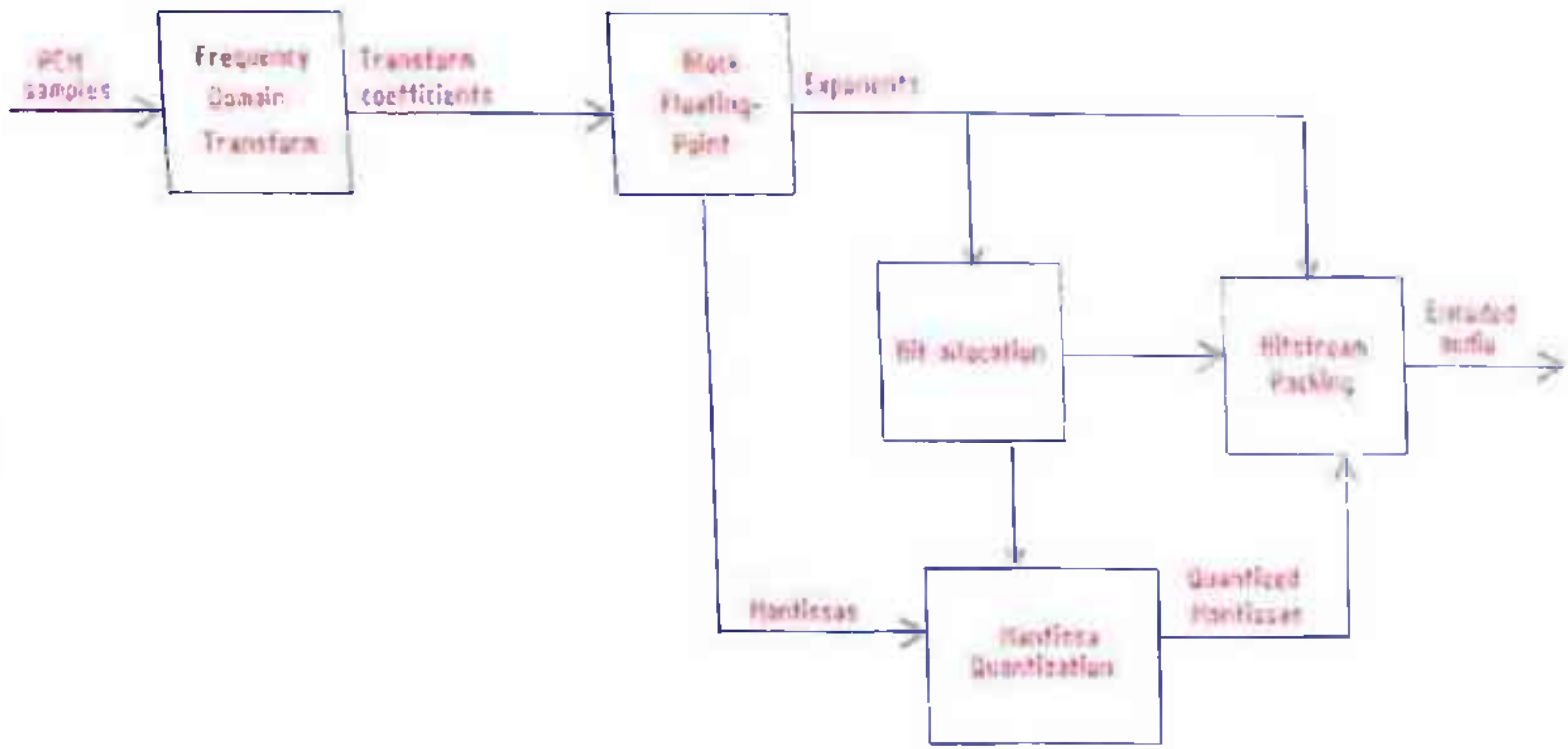


FIG. 3-1 AC-3 ENCODER BLOCK DIAGRAM

3.1.1.1.2 AC-2 coding

AC-2 coding technique[165] has been used for Digital Audio Broadcasting (DAB), multi-channel entertainment quality satellite broadcasting to cable head-ends. Inter-studio transmission, Digital studio to transmitter links (DSTL), Disk-based storage and digital cart machines, ISDN. At the encoder input, PCM audio samples are buffered into sample data blocks. Each sample block is multiplied by a window function and thereafter transformed into a set of frequency domain coefficients. The number of scalar transform coefficients per unit time equals the number of input samples in that time interval.

Adjacent transform coefficients are grouped into subbands which approximate the non-uniform width critical bands of human hearing. Coefficients within one sub-band are converted to a frequency block floating-point representation, with one or more mantissas per exponent. The transform coefficient mantissas are encoded by a forward-adaptive quantizer. For this purpose, the step size information is derived by dynamic bit-allocation routine which analyses the sub-band exponents. In the final encoder stage, the coefficient mantissa bits are multiplexed with exponent bits for transmission.

3.1.1.1.3 MPEG/Audio algorithms

With features such as low-cost and high-quality, MPEG technology has been widely adapted, especially in the applications - Digital Audio Broadcasting (DAB), Integrated Service Digital Network (ISDN), High Definition Television (HDTV), CD

ROM, Multimedia and Set-top box (STB) for video on demand (VOD). MPEG/Audio algorithms have a layered structure with layers I, II and III.

MPEG /Audio algorithms realize better compression rate than other algorithms. At the same time, the subjective tests for performance evaluation of MPEG/Audio algorithms have shown that there is no noticeable distortion[166, 167]. The MPEG shall be discussed separately in the video compression section.

3.1.1.2 Video data compression

Video signals have historically been driven by the characteristics of the analog CRT. Digital video standards followed this by providing a digitized form of the analog signal. The signal is both spatially and temporally intact and can be easily assembled into sequences of pixels and sequences of fields and frames which when transmitted can directly drive the CRT.

Computers and compression have moved us to an era where the digital signal no longer resembles its analog original. Not only the vertical and horizontal intervals are removed but the image is no longer spatially (and with MPEG, temporally) intact. In fact it becomes an unrecognizable sequence of bits. In next section, the video compression theory is described.

3.1.1.2.1 Video Compression Theory

JPEG, MPEG and H.261 standards have a number of things in common. The most important common factor is that they all use the discrete cosine transform

(DCT) algorithms. They each perform quantisation on the resulting DCT coefficients, and implement run-length coding on those quantised coefficients. The scheme of compression is shown in Fig.3.2. The various stages involved are stated below:

Discrete Cosine Transform (DCT)

DCT is a *mathematical transform* which translates digital video data from the spatial domain to the frequency domain. Typically, a coding algorithm divides *picture data into blocks of 8-by-8 pixels*, where a pixel is a picture element with a value from O to 255. It then performs the DCT on each block. For each block of 8X8 pixels, the DCT gives an 8X8 block of frequency components. Performing the DCT on the video data typically concentrates much of the picture information into the lower frequency components.

In the spatial domain, picture information is spread thinly over a large number of pixels. In the frequency domain, much of the picture information is contained in the lower frequency components. As a result, it becomes possible to discard some of the higher frequency components, without sacrificing much of picture quality. The DCT itself does not compress data but the process starts with quantisation and run length encoding. In the quantisation process, each of the DCT coefficients is divided by an integer and rounded to zero. In a typical picture, many of the higher frequency components will have low values, so their output

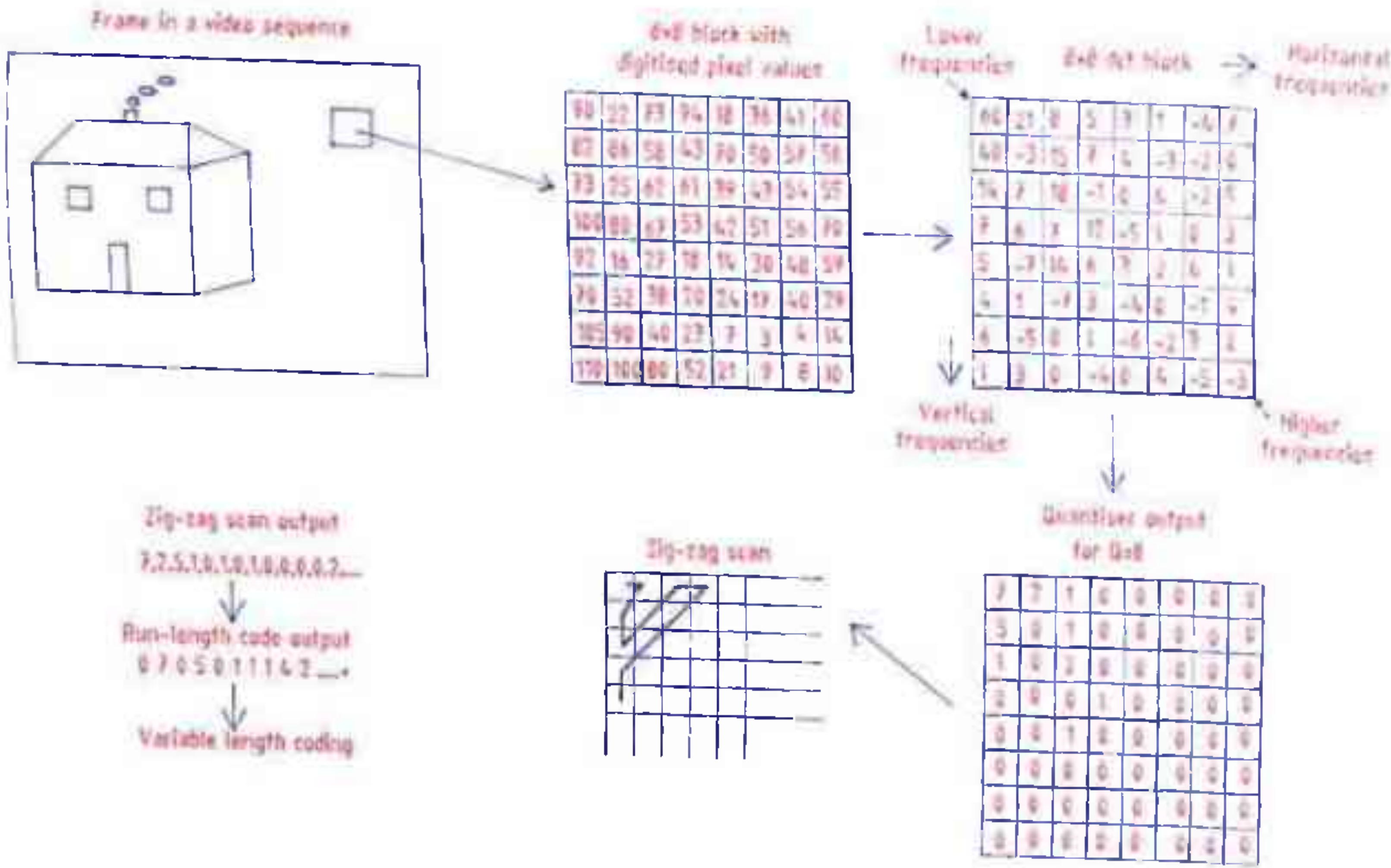


FIG. 3·2 DCT BASED VIDEO CODING SCHEME

after quantisation will be zero. The quantisation integer is user definable, or is adaptable, its value being determined by a control loop. In most cases, users can control how much of the high frequency components they wish to neglect. Thus compression can be achieved.

Run length coding is performed by zig-zag scanning of the quantised coefficients. Output of the RLC process are the values of each non-zero components, preceded by the number of zero valued coefficients before that component.

Variable Length Coding (VLC)

Further compression is achieved by the use of variable length coding. Here commonly occurring strings from the run-length coding process are assigned short code words, while less common strings are assigned longer code words. At this point, framing of the data can occur, so compressed data is now ready for transmission or storage.

Further techniques such as "prediction", "motion estimation" etc. are used to remove redundant data in motion video. Prediction is a technique where instead of coding and transmitting data for full frames, frame differencing is used. The encoder codes the difference between the current frame and a prediction of what that current frame should be. This could be achieved by simply subtracting the last frame from the current frame and use the difference. However this method is not used, because it doesn't take into account the error build up in the transmission channel To take care of this aspect, a decoded version of the last encoded frame from a feed back path, is used for prediction purposes.

Motion estimation and compensation is used to further eliminate redundancy. In this technique, the predicted frame is refined to take into account the motion which is estimated to have occurred between it and the current frame. This has the effect of making the predicted frame as similar as possible to the new incoming frame, so the frame difference will be minimized even further.

3.1.1.2.2 Need for different Standards

While the video standards have some common features - in particular the fact that they all use discrete transform - they are distinctly different and are geared towards different applications. For example, JPEG could be used for motion video applications, but it would never achieve the same real-time performance as H.261. This is because it does not have inter-frame and motion compensation capability.

3.1.1.2.3 Still Image Coding - JPEG

Standard ISO 10918, more commonly referred to as JPEG, defines the techniques to be used in the coding of still pictures. A number of options in the JPEG standard, allow users to tailor their system for different levels of compression and picture quality. The forward process of JPEG consists of DCT, quantisation, zig-zag scan, run length coding and variable-length coding. Since JPEG caters to still pictures, frame prediction or motion compensation is not needed. The JPEG compression algorithm is shown in Fig. 3.3. It also does not require a feedback loop. JPEG intra-frame compression is shown in Fig. 3.4.

JPEG uses both lossless and lossy coding techniques. In lossless coding, the picture can be rebuilt exactly as it was prior to coding. Lossless coding achieves limited compression. It is 'prediction' based and not DCT based. Imaging for medical purposes is an example of a situation where lossless coding is required. Lossy coding techniques are based on the DCT and use sequential coding, progressive coding or hierarchical coding. Sequential coding is the simple DCT process. Progressive coding allows a progressive build up of picture quality. In this mode, lower frequency components followed by the higher frequency components of the quantised coefficients are stored or transmitted. Alternatively, the resolution of the coefficients are selectively increased so that the most significant bits are first processed, followed by the least- significant bits. In hierarchical coding, resolution of the picture gradually builds up.

The progressive and hierarchical schemes allow the user to select a variable quality level for a still picture. This is important if a JPEG picture is to be transmitted from one location to another. For on-line browsing of video pictures using a slow transmission channel, this has special significance. In a broadcast application, the delivery can be through systems like ISDB (Integrated Services Digital Broadcasting), and pictures of video using data Channel viz. Internet. Sending a very high resolution picture could take a long time. As a result, it might

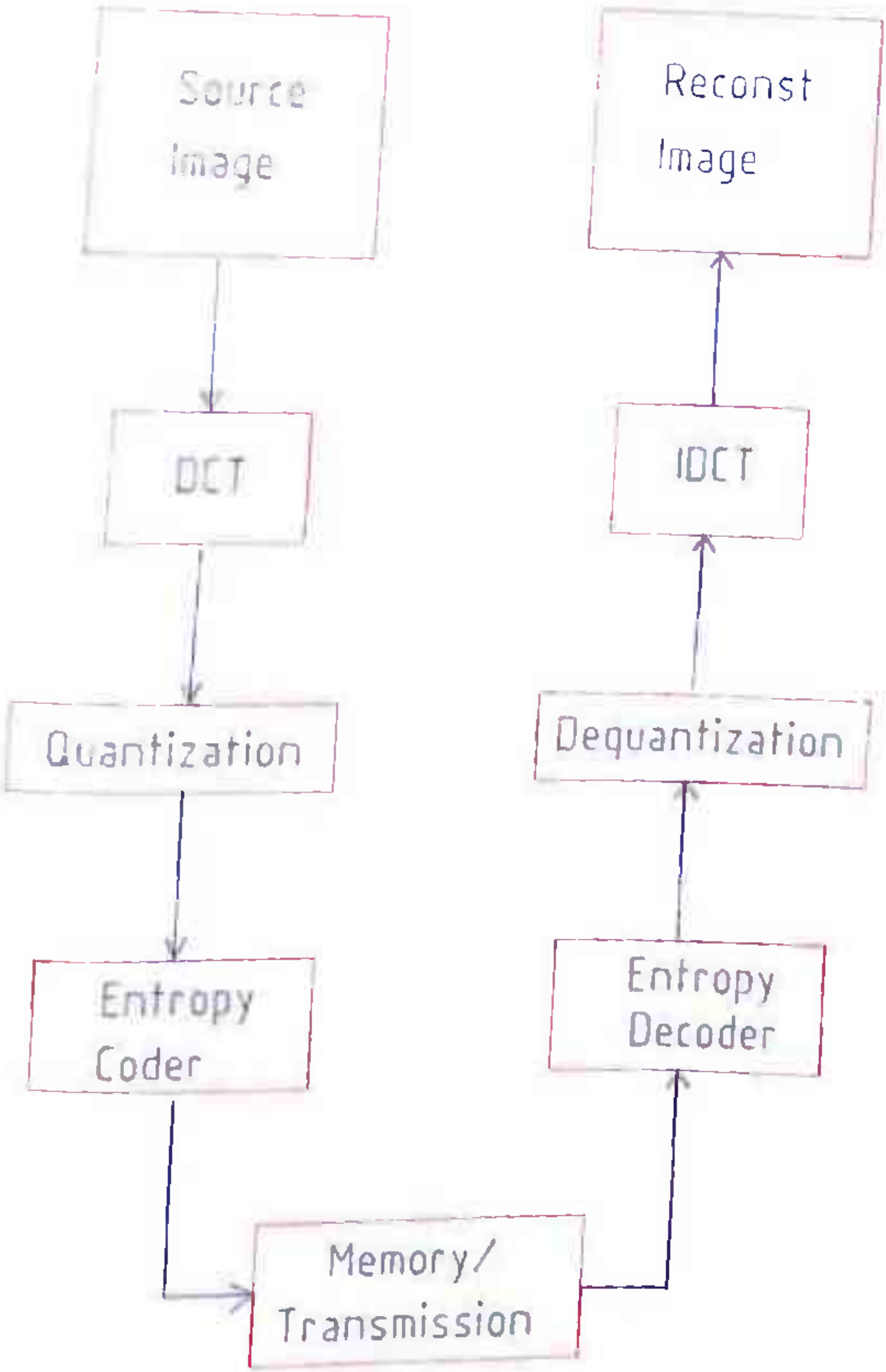


FIG. 3.3 JPEG Algorithm

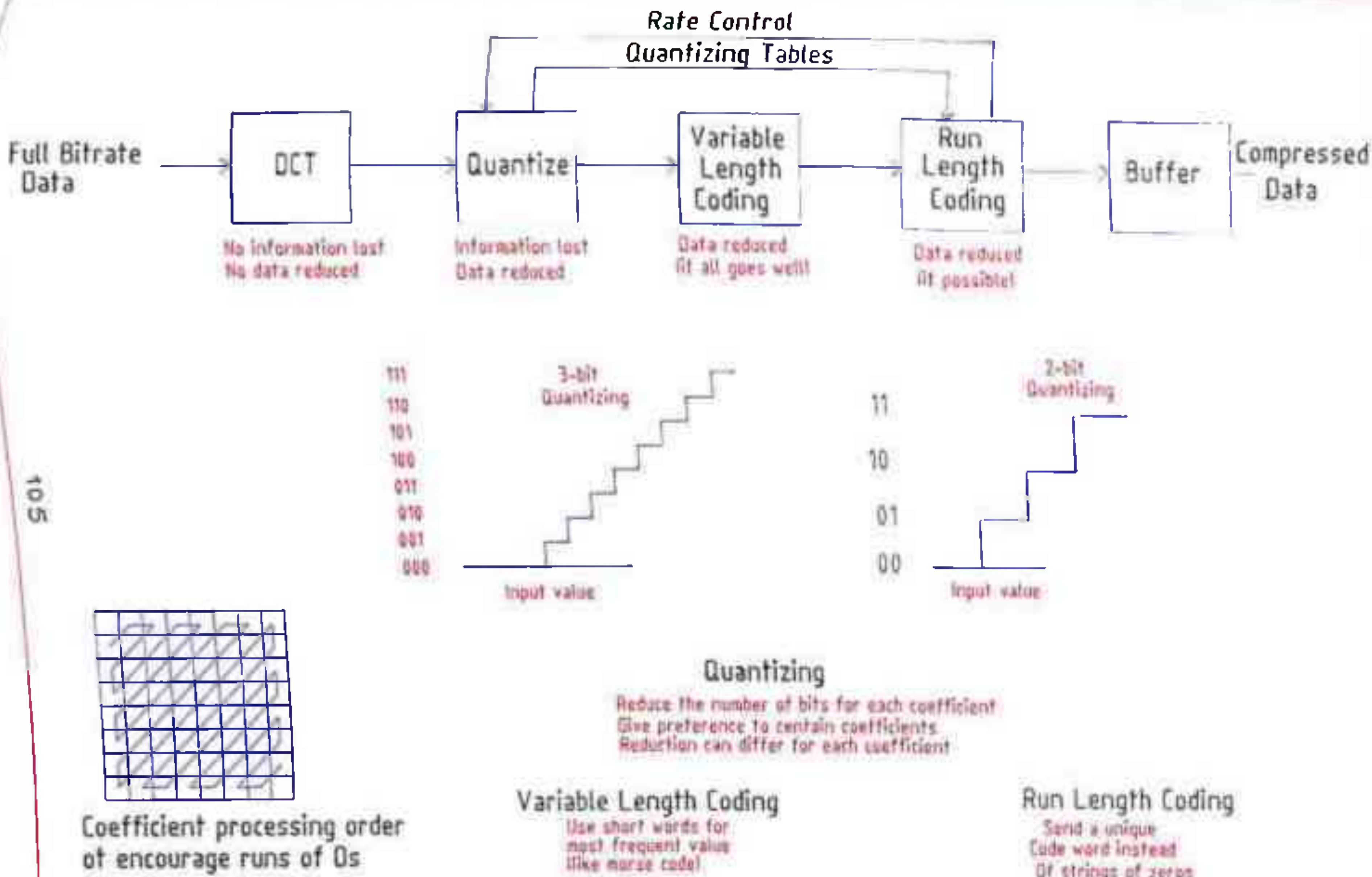


FIG. 3.4 JPEG INTRA-FRAME COMPRESSION

be desirable to send lower quality video. In a browse type application, the receiver could then select specific stills and request those in greater detail which could then be sent through ISDB full video channels..

3.1.1.2.4 Video conferencing - H.320 and H.261

Video conferencing standards -H.320 and H.261 are geared towards ISDN. As such, transmission of coded audio/visual data is normally at a multiple of 64kbit/s - the bandwidth of one ISDN channel. Normally in a single ISDN channel, 16 kbit/s would be required for audio leaving 48 kbit/s for video. Bigger stand-along systems usually operate at between 128 and 384 kbits/s.

The compression algorithm in the H.261 standard operates on Y(luminance), C_r(Color difference ~U) and C_b (Color difference ~V) digital data. Two resolutions namely CIF and QCIF, have been specified for the source data (Table 3.3).

Table 3.3

CCIR-601,CIF and QCIF resolutions

Format	Y_{hor}	Y_{vert}	Cr_{hor}	Cr_{vert}	Cb_{hor}	Cb_{vert}
CCIR-601	720	576	360	576	360	576
CIF	352	288	176	144	176	144
QCIF	176	144	88	72	88	72

An H.261 compatible decoder must be able to decode a stream which had QCIF as its origin, but CIF is optional. Most system accommodate both resolutions. A system which encodes CIF data to a single ISDN B channel compresses video by approximately 60:1.

H.261 is a DCT based standard. Frame prediction is used with motion compensation in the encoding process. The standard details the syntax for the coded bit stream and specifies how the decoder works. However many encoder options such as motion estimation and compensation, are left to the user to implement.

3.1.1.2.4.1 Motion estimation and compensation

The current frame data is divided into 16-by-16 pixel 'macro-blocks'. Each microblock is compared to other micro-blocks in the last decoded frame, to a displacement of plus or minus 15 pixel in each dimension. A calculation, such as the sum of the absolute differences between each corresponding pixel in the 16-by-16 micro-blocks is made. The nearby micro- block which gives the minimum overall difference is used to determine the best match. Motion vectors are calculated based on this match and sent to the decoder. The predicted frame is adjusted using the motion vectors, and frame differencing is done for compensation.

Variable length codes are fed into output buffer which has a variable input rate and fixed output rate determined by the bandwidth of the transmission channel. If the buffer overflows, picture information is lost. The buffer overflow generally occurs when there is sudden or rapid movement due to the high degree of motion between scenes in the picture being encoded.

To eliminate corruption as a result of buffer overflow, input to the buffer is controlled. Buffer control is achieved by monitoring the buffer fullness, and adjusting parameters such as the quantisation values. The system also decides whether or not to use frame prediction and motion compensation, and could also decide to drop the frame rate by skipping some frames.

The annoying features of the frame drops are poor lip to speech synchronisation, smearing on the screen where the movement is occurring, and jerkiness in the picture.

3.1.1.2.5 Video over the phone - H.263

ITU-T accepted a new standard - H.263 in march 1995, for 'Video coding for narrow telecommunications channels at 64 kbit/s'. The H.263 standard was developed for use over the normal telephone line for the videophone market or for PC users. However, these standards are being evaluated for use in broadcasting for low quality news clips. H.263 operates more effectively at low bit rates since it uses QCIF picture format at 176 by 144 elements or sub-QCIF at 128 by 96. It will be possible to implement it with a range of options up to and including use of a V.34 modem at 28.8 kbit/s. In this case this standard could be used for sending video through Internet.

As with H 261, H 263 uses block based methods for compressing and coding video signals. The DCT is used to derive frequency content information from the original spatial information. Quantisation, differential coding between frames, run length and variable length coding techniques are used for compression and coding. Motion estimation and compensation can be used in the differential (Inter) coding process.

H 263 uses a 'PB' frame which consists of two pictures coded as one. The P frame is the normal predicted frame. The B frame is derived using bidirectional prediction from the two adjacent P frames, fitting in between these two frames.

3.1.1.2.6 MPEG-1 and video CD

MPEG-1 is an ISO/IEC standard. Originally developed to provide a standard for the storage of audio and video on digital storage media, the standard is optimised for operation at about 1.5 Mbits/s. This is significant because it is the data rate for an uncompressed CD and it is also suitable for digital audio tape. There are three parts to the standard: audio, video and system. Typically the audio takes about 192 kbits/s of this bandwidth, video takes approximately 1.15 Mbps and balance is needed for the system data stream.

Certain requirements in accessing stored video and audio have played a large part in the development of this standard. Access to the stored material is important and facilities have been inbuilt for random access, fast forward and reverse, and reverse playback. The synchronisation of audio and video is also very important and error robustness is also inbuilt into the system.

MPEG compression uses both intraframe and interframe compression; Motion-JPEG and other video compressors use intraframe encoding exclusively. MPEG encoding starts by compressing a single "picture" or video frame using intraframe algorithms very similar to M-JPEG. Intraframe compression eliminates redundancies in a single picture, called an I-frame (or I picture) in MPEG terms. Large blocks of a single color, for example, get replaced with a small amount of information. Interframe compression goes a step further to remove redundancies between successive frames or pictures.

To create the I-frame, MPEG makes a reference frame at a distance M (normally three) frames past the I-frame by calculating the difference between this "predicted"; or P-frame, and the I-frame. Next, MPEG calculates differences for the frames between the I-frame and P-frame, in a sequence like IBBP, for example. It compares each "bidirectionally predicted" frame, or B-frame, with the preceding reference frame (an I-frame in this case) and the next reference P-frame, and it uses whichever differences are smaller. This means that MPEG "predicts" some B-frames from parts of "future" P-frames, and MPEG works best when there is little change.

This requires MPEG to transmit frames out of their normal order for playback. The IBBP sequence to transmitted as IPBB (Fig. 3.5). MPEG therefore needs

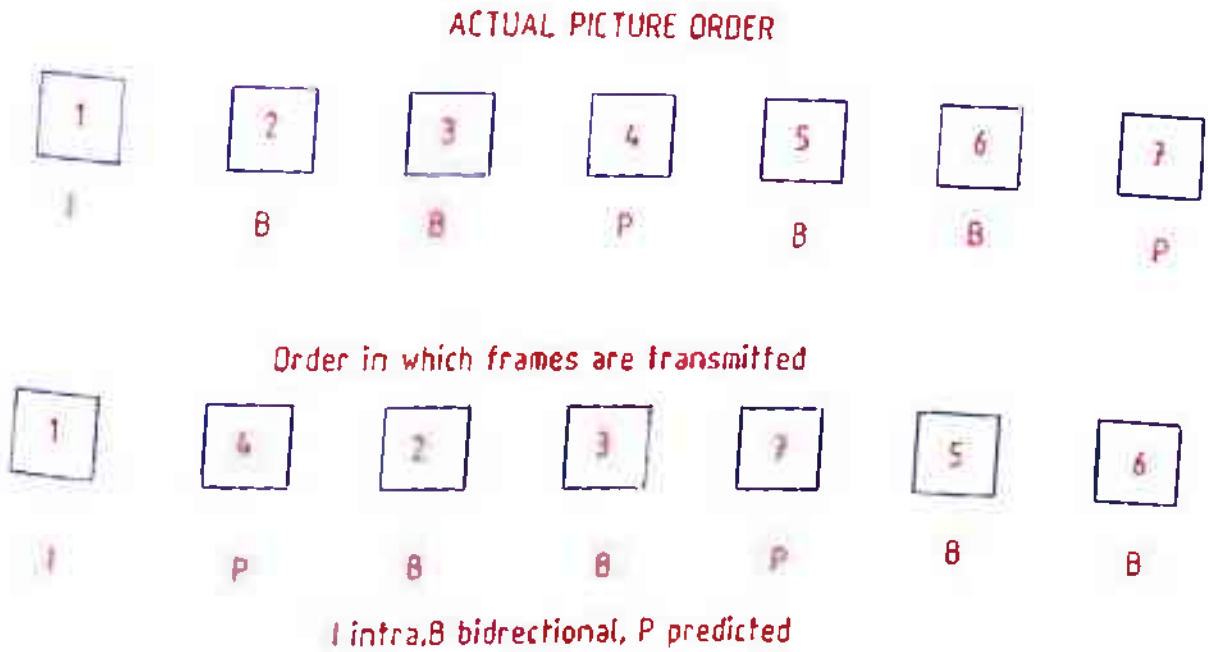


FIG.3.5 TRANSMISSION OF MPEG 1 FRAMES

buffers large enough to store the I and P reference frames, and the differences for each B before it can rebuild them to re-create the sequence IBBP for playback. Interframe compression continues with a second P-frame, which now uses the first P-frame as the reference for its differences and more B-frames to produce IBBPBBP. Errors in a P-frame can propagate forward until the next I-frame starts the process over from scratch. If there is a major scene change before the next I frame, MPEG image quality deteriorates drastically.

Normal MPEG has four P-frames between I-frames, for an intraframe distance of N = 5*M = 15. This looks like IBBPBBPBBPBBPBBI. A group of pictures (GOP) contains at least one such sequence from I frame to I -frame, and may contain several I-frames. For Video CD, the maximum number of I-frames in a GOP is four (normally two seconds). Most of the MPEG encoders allow adjustment of M (the distance between reference frames), N (the distance between I-frames) and the number of I-frames in a GOP[168].

Unlike video conferencing standards, MPEG tends to be quality controlled rather then bit rate controlled. Certain parameters are specified which give a certain quality level, rather then, say, setting the system to operate at a particular bit-rate such as the bandwidth of an ISDN channel.

3.1.1.2.7 Coding for broadcast systems

MPEG-1 and H.261 use CIF resolution by dropping one field per frame and further dividing the remaining field. This lowering of video resolution causes a subsequent loss in video quality, so while it is acceptable for PC conferencing systems, it is not suitable for studio broadcast. MPEG-2 addresses broadcast technologies using the CCIR 601 recommendation and finds it's application in catv, digital television, video- on- demand and DBS.

MPEG-2 has different 'profiles' and 'levels' so its use can be tailored to a particular application. A particular profile places limitations on the syntax of the encoded video, while a particular level limits parameters such as frame dimensions or sample rates. Low level MPEG-2 involves the use of CIF resolution with a bit for the encoded data up to 4 Mbps, while main level studio TV applications requires CCIR 601 resolution. Most decoder chips will be capable of operating at main profile, but higher profiles could include features such as spatial scalability. The syntax in MPEG-2 can be divided into two main categories - a scalable syntax and a non-scalable syntax. The non-scalable syntax is structured as a super-set of MPEG-1, but there are extra tools for handling interlaced video. When handling interlaced video, MPEG-2 allows a frame to be selectively treated as a single picture. Alternatively it allows the two fields to be coded individually if there is a lot of motion in a picture. MPEG-2 has scalable syntax which means that it incorporates all the functions available in MPEG-1, such as random access, fast forward and reverse and reverse playback. All MPEG-2 decoders will in fact be able to decode an MPEG-1 bit stream. The scalability will also result in MPEG-2 finding applications in transmission media such as Asynchronous transfer mode (ATM) which do not have constant bit rate.

There are three types of scalability in MPEG-2, namely signal-to-noise ratio, spatial and temporal. Each of these scalable extensions uses the concept of a base layer and an enhancement layer. The lower base layer is used for a basic video quality, and the higher enhancement layer is used to improve the quality already available from the lower layer. This is useful in applications such as transfer of video over an ATM network, or in general over a channel with a variable bit rate.(The variable bit rate coding is shown in Fig 3.6)

An error-robust channel can be used to transmit the base layer video. However, the enhancement layer could be transmitted over a channel which was not so error robust, or was likely to be congested. Since it is for enhancement only, it dose not affect the basic video quality if corrupted, or if it fails to reach the decoder. In temporal scalability, the base layer provides a basic temporal resolution (frames per second), and the higher layer is coded with temporal predictions for further enhancements. The enhancement layer for spatial scalability provides a coded difference signal based on an interpolated prediction of the lower layer. In the case of signal-to-noise ratio scalability error information produced in the encoding process might be used.

MPEG-2 has been currently accepted as the world standard for broadcast purposes. Digital Video Broadcasting (DVB) using MPEG-2 standards for Source Coding and Multiplexing has allowed five Standard Definition TV (SDTV) programmes on a 33 MHz transponder with a data rate of 38.1 Mbps .

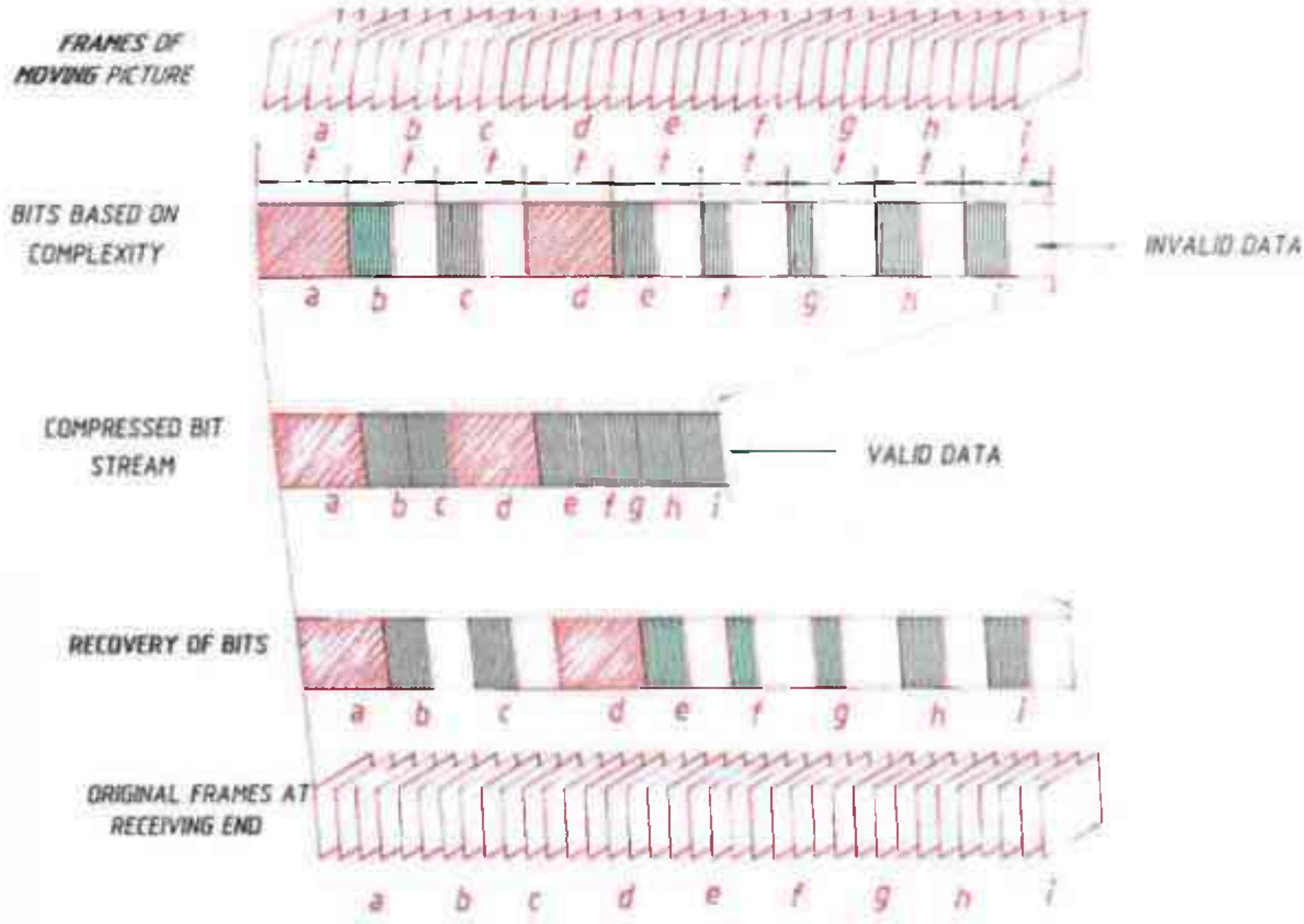


FIG. 3.6 VARIABLE BIT RATE CODING

3.1.1.2.8 Compression Techniques for Cyberspace Broadcasting

Several application specific compression techniques are used for authoring audio and video on Web. The control over encoding parameters viz. video and audio bit rates, distance (M) between reference frames, the distance between intra-coded I frames, number of I frames in a group of picture (GOP), intradistance (N) etc. have been exploited to develop several lossy compression techniques which can provide greater compression. These lossy compression techniques have been used for digital broadcasting through low band-width Cyber-space (INTERNET). Audio and Video including multimedia, animation and virtual reality scenes are already available on many sites.

Meta Voice compression algorithm is best suited to low band-width (2400 bps) speech broadcasts. LBR (Low Bit Rate) compression algorithm has been found to be suitable to provide crisp and clear speech and music on 28.8 Kbps. Video has two components that affect the overall result: the absolute quality of individual frames and the number of frames displayed per second. The approaches available are high quality low-frame-rate or full motion and degraded frame quality. The lossy compression techniques available are Prediction (Motion Compensation), Frequency Oriented Compression, Importance Oriented Compression, Sub Sampling, Vector Quantisation, Hybrid Coding, Fractal Block Coding etc. The lossy techniques used for authoring video on the Web are described below.

3.1.1.2.8.1 Derivative of MPEG

The compression is controlled by selecting the number of *I* (intra-frame), P *(predicted-frame) and B (bidirectional interpolated)* frames. For example at lower data rates, only higher-quality I-frames are selected and B and P- frames are completely dropped. The advantage is that a user with high bandwidth network like T-1 can access stored video at full frame rate while a user with 28.8 Kbps modem might receive frames at a slide-show frame rate maintaining good image quality.

The technique has been used to create audio/video streams ranging in bandwidth from 28.8 to 150 kilobytes per second and providing crisp, high quality frames at receiver that often move like a slide show than video on a 28.8 kbps modem.

3.1.1.2.8.2 Wavelet Algorithm

Characterized by high quality, dynamic bandwidth management and scalability, the compression is achieved by dividing each video frame into multiple layers and then dropping the layers depending upon the availability of bandwidth. In this technique, lower bandwidth results in degradation of picture quality but motion and audio are preserved. Wavelets remove blocking artifacts by the fact that their basic functions are overlapped one another and decay smoothly to zero at their end points. The scheme achieves higher compression ratios for a given picture quality and is simpler to implement to achieve real time performance for video sequences. Due to lack of blocking effects, the errors introduced in the scheme are less visually annoying than for the DCT compressed images.

In wavelet transformation [169,170,171], the input signal is splitted into number of bands by applying low pass filter L and high pass filter H in both horizontal and vertical directions. The filter outputs are sub-sampled by a factor of two, generating three orientation selective high pass sub-bands, HH, HL, LH and a low pass sub-band LL. The process is repeated on LL band to generate the next level of decomposition. Four octaves of decomposition leads to 13 sub-bands. The image data is compressed by controlling the transmission of coefficients and number of bits to code them. Each group of transform coefficients are gathered according to their spatial position and quantized. The quantized transform coefficients are thereafter scanned out from lower frequency block to higher frequency block followed by variable length coding. The scanning path is chosen to increase zero run so that the efficiency of entropy coding is improved.

3.1.1.2.9 Very Low BIT Rate Coding using Model Based Approaches

To avoid blocking and mosquito artifacts at a very low bit rate, Object based and Knowledge based codings are being investigated. In Video applications, set of parameters defining the motion, shape and texture of the moving object, wire frame model and the changes in the structure from frame to frame etc. can be used to synthesize the next frame at the receiver side. [172]

3.1.1.2.10 MPEG-4

The block based coding used in the presently available standards decomposes the image into blocks which are encoded independently of each other. The limitations of this approach are 'blockiness', non-definition of objects in the picture etc. The result is that a limited number of functions can be added to the system. Work has already begun on a new standard MPEG-4 The main features of this standard shall be:

- content based accessibility and manipulation,
- support for interactive communication,
- user's ability to identify objects in a picture and tracking the movement of those objects.

MPEG-4 may open new uses for multimedia, such as the retrieval of information from on-line libraries. One may be able to browse through a moving picture, click on an object in the picture and download more information on that item. MPEG-4 standard, with target for a very low bit rate (LBR) between 4800 to 64000 bits per second is expected by November 1998.

3.1.1.2.11 Emerging standards and Scenario

New standards encompassing even more applications are emerging. One possibility is that H.263 will enable good quality video broadcasting over the ordinary telephone line. With MPEG-4, there will be new functions, coupled with improved compression ratios and picture quality.

The compression techniques will result in multimedia broadcast systems which will encompass services like multi-channel, multi-lingual, mobile and data delivery systems.

3.1.2 Storage Media -Video Servers

Video distribution and archiving until now have always used traditional video equipment like video tape recorders, telecine, etc. These used analog format. Even after the advent of digital technology, large bandwidth requirement forced the broadcasters to continue with the traditional equipment. Compression has presented a dilemma. In order to distribute or archive compressed video data using traditional means, it must be decompressed on output and is likely to be re-compressed on input which causes a new from of generation loss. In recent time design of mass storage system for multi-media applications has become an active research topic [173]. The Video server apart from the storage system, includes computer network and SCSI interfaces to distribute and archive compressed video as data, avoiding generation losses and taking advantage of standard computer network and tape transports.

3.1.2.1 Video server theory

Video servers provide on-line access to the digital video stored on hard disks. At a conceptual level video servers have the ability to instantly access multiple simultaneous streams of video. The key components of a video server and some fundamental rules under which these components operate are described below.

3.1.2.1.1 RAID (Redundant Array of Inexpensive Disks)

RAID (Redundant Array of Inexpensive Disks) was invented in the early 1970's to increase the reliability of a disk system in case of a drive failure. Digital disk devices from the outset are designed as data stores and rely on many of the recording techniques developed within the data industry viz. finite size block of data each individually addressed and accessible. As such RAID makes an excellent choice for the video server.

RAID levels 0 through 6 are now defined, but the most common are RAID 0, 3 and 5. Level 6 is yet to be implemented. The various levels of RAID implementations are described below.

- *RAID 0 : Stripes the data across the array.* No data protection.
- *RAID 1 : Mirrors the data on two discs.*
- RAID 2 : Not used with PC-based systems.
- RAID 3 : Calculates parity as the data is striped across the array. One drive in the array is reserved for the parity information. Any single drive failure will not result in a loss of data.
- RAID 4 : As RAID 3, but works at a sector level for higher effective performance.
- RAID 5 : The same as RAID 3, however, the parity data is rotated across the array instead of one disk.

RAID 0, 1 and 2 are unacceptable for broadcast applications because a single drive failure will result in the loss of all data. Most systems today employ RAID 3 or 5. RAID correction error perfectly corrects all errors and disk failures. For critical broadcast applications, hot swap capability or transparent disk rebuild capacity are also required.

Apart from storage and reliability, disk arrays are also required for creating the bandwidth to support multiple channels which may access the same data simultaneously. A disk array with RAID provides both increased bandwidth as well as data protection. (For RAID 3 configurations, Net bandwidth = approximately the individual disk bandwidth X number of drives in the array - parity drives)

3.1.2.1.2 Controller for Traffic Management

A controller internal to the server manages the movement of data on and off the disks to the appropriate I/O channels. This controller also accepts real time commands such as play and record, given by the automation or other application software. The internal controller also interfaces with the external application for database checking. For example, when a Cue Sheet has been entered and where traffic has given the automation a playlist, the automation software needs to ensure that all material is available on the server, or otherwise notify the operator. This is accomplished by passing the playlist to the server to check with its internal database for inclusion of all those records.

Choices for controllers today are real time Unix systems and PC platforms. Real time Unix systems are designed to manage multiple simultaneous video channels with a precise allocation of time to individual processes. PC platforms are widely available, but their operating software is not designed for real time interrupts and multiple simultaneous processes.

3.1.2.1.3 I/O Cards

I/O cards configure a server for a specific application. They are responsible for taking incoming information, video and audio, formatting it correctly, compressing and then moving it onto the high speed bus, or vice versa for outgoing channels. In a modular design, all other components of the video server are completely independent of the I/O card. Upgrading the server for new video format or compression algorithms (For example, MPEG1 compression to MPEG2) can be done by changing only the I/O card.

3.1.2.1.4 High Speed Internal Data Bus

The purpose of the internal data bus is to move video and data as fast as possible from the disk array to the I/O cards and vice versa. A video server dose no computation on the video stream, unlike an effects generator or other device that manipulates video. Therefore, a bus that bypasses the internal controller is optimal. By not going through the CPU, the server is optimized for the fastest possible data transfer between the disk and I/O.

PCI and VME buses are common standard in the computer industry and have a large number of supported configurations and manufacturers. Current practical maximum speed of the PCI and VME busses are approximately 320 Mbps. In evaluating these bandwidths, it becomes apparent that they are a potential bottleneck of channel capacity in a server. Forgetting physical limitations, utilizing a JPEG compressed signal at 48 Mbps or a MPEG compressed signal at 6 Mbps, a server can only theoretically contain 6 to 54 channels, respectively. Utilizing a server with MPEG's bandwidth advantage for the same picture quality, most transmission application can be satisfied with current standard.

3.1.2.1.5 Disk Scheduling

Disk scheduling is the movement of data to and from the specific disk drives in the correct order, and the placement of that data in real time on the internal data bus. (Disk scheduling also controls the reverse of this process for putting data onto the disk drives). In other words, it is the mechanism which makes play, record, stop, pause, fast forward, rewind, etc. a reality in a multi-channel environment. Disk scheduling algorithms for the demanding requirements of broadcast applications are designed by each manufacturer. Today, they are one of the most likely components to limit the bandwidth of a video server, even more so than the internal data bus, because a scheduling algorithm reduces available bandwidth to guarantee that each channel has adequate bandwidth. In doing so, the maximum available bandwidth from the disk array cannot be utilized. Manufacturers continually strive for improvements in scheduling algorithms to better utilize the available disk array bandwidth.

In looking at the individual components that make up a video server, two areas that are potential bottlenecks for a server with very high channel capacity are : disk scheduling and the internal data bus. Digital technology will continue to advance and new capabilities will become available over time to help eliminate these problem. But, at the same time, broadcasting requirements will also increase, both in number of channels and quality (i.e. HDTV).

3.1.2.1.6 Program and data on Servers

Video server apart from holding the audio and video files, contains software for broadcasts and post production. A system administration program provides facilities for resource allocation and security. An interface program provides random-access VTR emulation to work with most existing editing and graphics systems. It consists of VTR protocol software and a virtual control panel which runs on a workstation. However, the growing trend is to have a video (media) server for multimedia data and a separate server for RDBMS.

3.1.3 Delivery System

Archive holdings can be presented or delivered in many different forms. For example, users might find what they are looking for by browsing abstracts or thumbnail images. After they find what they want, they can requisition / order the complete version. The archive might deliver the materials on a CD-ROM, floppy disks, on paper, or it might deliver the materials through a network.

Digital information can be very large in size, putting a strain on many existing network capabilities. Not only is sufficient bandwidth required, but real-time delivery of audio and video are dependent on a paced, continuous delivery of data over the network.

Today's public and private network effectively transport extremely large amount of information. They provide a high degree of quality, guaranteed service and good response time for meeting the networking needs of today's broadband applications. But as high bandwidth, integrated voice, video and data applications grow in popularity, both public and private networks are feeling the strain. They simply were not designed to provide the transfer speed or enormous bandwidth required by integrated voice and video applications.

Today's LANs are interconnected primarily through packet-based bridges and routers. LAN bridges are simple to implement and provide a fair degree of traffic segmentation. Routers, though more complicated, provide a greater degree of segmentation. One limitation of both however, is the time it takes for packets to pass through time. This packet latency is not a major problem for data, but causes problems when transmitting time sensitive and video applications.

Bridges and routers introduce variances in audio and video signals that the user can hear as pause in sound or see as distortion in the picture. Transferring voice and video networks with bridges and routers typically result in less-than-perfect voice and image quality, which may not be acceptable depending on the application, albeit these can be used for transferring information about the holdings in the archives.

Scalability in a network is the ability to increase the amount of bandwidth without changing the information structure. Today's LANs do not scale well. Typically, adding more bandwidth in today's network means implementing a different LAN technology, such as converting from Ethernet to FDDI.

Broadcast networks are changing to digital. We had described about the DAB, DVB, DSS and ISDB concepts of broadcasting in Chapter 1. However, the broadcasters are talking of interactive broadcasting where there is constant interaction with the viewer /listener. The beginning was done with the "phone-in programme'. However, it is not able to provide full interactivity where listener /viewer may define their own channels or video-on-demand type of programme. Therefore new methods of delivery such as DTH in ku band, broadband networks or Internet are also being explored for delivery of multimedia data directly to listeners/viewers. These networks shall supplement the existing modes of broadcasting.

3.1.3.1 Broadband Networks

Network administrators are faced with a dilemma: how to implement network that not only meet today's needs, but provide a clear and cost-effective path to meeting tomorrow's needs as well. A difficult task, considering that today's needs seem to be in a constant state of flux. The number of users on the network is dramatically increasing. New, 64-bit graphical workstations are bringing power to the desktop that will require real-time network performance. Multimedia applications with an appetite for consuming huge amounts of bandwidth loom on the horizon.

While networks must evolve to meet the changing demands placed on them, this dose not necessarily spell out the wholesale destruction of our existing network infrastructure. With insight and proper planning, we can protect our investment while pursuing a smooth migration from today's data network to the information network of tomorrow.

3.1.3.1.1 Asynchronous Transfer Mode (ATM)

Asynchronous Transfer Mode (ATM) was developed as a switching technique for data and packet in AT&T laboratory in Naperville, Illinois, USA in 1980. ATM is an emerging technology that uses a very flexible method of carrying broadband (i. e. voice, video and data) information between devices on a local or wide area network at extremely high rates typically 155.52Mbps or 622.08 Mbps[174]. Developed by the telecommunications industry to provide broadband services over the public network, ATM uses key components of today's telephone and data network to carry real-time voice, video and data over a single network [175]. ATM transport fixed-sized packets, called cells, on a per-established channel to carry information between workstations on a network . Each cell is a short packet of 53 bytes with 5 bytes as a header followed by a fixed data field of 48 bytes

[176]. ATM cells can be carried on any number of physical transports, from 45Mbps up to the gigabits range, without changing the cell format of the cell switching mechanism.

ATM is connection oriented in the sense that every cell must travel the same route in a high speed ATM network. The bandwidth within the network connection is scalable - it can be allocated based on the application's required quality of service (QOS). ATM networks can provide consistent bit-rate service with only small network delays, which is required for video traffic. The most notable application of ATM is the transport of real-time video over a network. A user can dial up the servers and watch videos on-line. ATM uses a service interface known as ATM Adaptation Layer (AAL) to accept traffic from higher level protocols and applications. So far, ATM Forum has defined five AALs but most frequently used are AAL 1 for constant bit rate traffic (CBR) and AAL 5 for VBR traffic. AAL 1 creates problems for MPEG-2 video since traffic is bursty. (MPEG-2 sends a reference frame followed changes.) AAL 5 designed for VBR also creates problem for audio and video and therefore industry is using AAL 1 for distributing VBR multimedia data using AAL 1 [177].

The type of media suitable for ATM is not limited by ATM cell technology itself, but by the physical transport. ATM cells can be transmitted over any cable, however the speed and bandwidth of the interface will dictate the type of media. As mentioned previously, the ATM Forum is specifying types of interfaces, each of them will dictate the type of media that can be utilized.

The DS3 specification is intended for interfacing to the telecommunication environment, which is typically coaxial or fibre optic cable. Due to the low bandwidth, DS3 interfaces may be suitable for unshielded twisted pair (UTP) in LAN applications

The 100Mbps (FDDI) interface specification is tragetted directly at LAN application, and is intended to take full advantage of the recent development of FDDI over UTP/STP cable. The 100Mbps ATM interface will also support 62.5/125 micron multinode fibre optic cable. The 155Mbps rates will initially be run over multimode or single mode fibre optic cable. However, future developments may allow these rates to be transmitted over twisted pair cable as well. All transports greater than 155Mbps will run strictly on multimode or single mode fibre depending on the rate.

3.1.3.1.2 Synchronous Transfer Mode (STM)

The capabilities and limitation of today's network can actually be attributed to the underlying transfer modes - the way in which information is organized prior to being transmitted. Today's public network use a method known as Synchronous Transfer Mode (STM).

STM was developed for transmitting voice and video information for real-time applications over public networks. It uses a time division multiplexing (TDM) scheme to provide dedicated circuit-oriented capabilities. The telecommunications industry uses STM as the physical transport method for DS0 (56/64 kbps), DS1 (T-1: 1.544 Mbps), DS3 (T-3 : 45 Mbps) and emerging SONET (Synchronous Optical NETwork) wide area network services. SDH (Synchronous Digital Hierarchy) is the European equivalent of SONET. In essence SONET and SDH are the same technology with minor differences in header information, payload size and framing. SONET/SDH offer data rates of 51.84 (OC1), 155.52, 466.56, 622.08 (OC-12/STM-4), up to 2488.32 (OC-48 /STM-16) Mbps. Typically SONET /SDH are being deployed at 2.4 Gbps. Standards are being worked out for 2.4 Gbps [178].

3.1.3.1.3 Packet Transfer Mode (PTM)

PTM, developed for transmitting data communications within private network, transports data based on varying sized and formatted packets, each with its own addressing information. PTM is implemented primarily in local area networks through technologies such as Ethernet, token ring and FDDI It is also used for wide area networks through X.25 and frame relay technologies

3.1.3.1.4 STM vs. PTM vs. ATM vs. SONET vs. SDH

STM is ideal for voice and video, while PTM is ideal for data. The reverse, unfortunately is not true. STM provides constant bandwidth which is good for voice, but is inefficient for bursty data (MPEG-2 compressed video). PTM provides flexible use of the available bandwidth, but dose not provide the fast, guaranteed network access required by time dependent voice and video applications.

ATM addresses the limitation of STM and PTM and provides the flexibility and scalability required by emerging network applications. In addition, ATM is a single network technology that efficiently supports voice, video and data communications through a single network infrastructure.

SONET, SDH, and ATM differ from data services like Frame Relay and SMDS (Switched Multimegabit Data Service) in that they serve as both address carrier infrastructure and consumer services. SONET/SDH and ATM can be seen in terms of layered architecture as shown in Fig. 3.7. SONET and SDH are at the bottom (layer 1 of the OSI stack) and furnish a transmission mechanism for high speed communication services like ATM. Other services like frame relay and voice can ride on top of them.

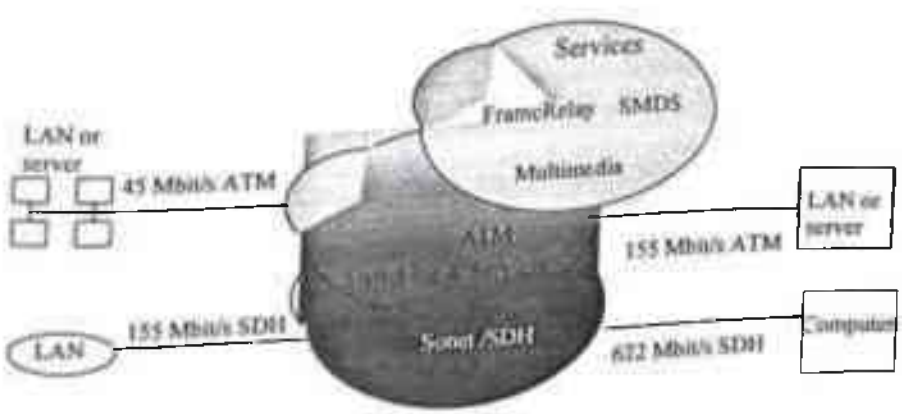


Fig. 3.7 Stacking up the Services

3.1.3.1.5 Broadband ISDN (BISDN)

In 1988 at a Comite Consutitif Institute de Telegraphe et Telephone (CCITT) meeting in Seoul, South Korea, recommendation was made to use ATM technology for Broadband ISDN (BISDN) [179]. BISDN is a standardized public switched telecommunications infrastructure. BISDN, with the cell switching as it's core technology [180], is the future network that will provide a wide range of services using a limited set of connection types and multiple user network interfaces. The low end provides 64 Kbps transmission services, both circuit switching and packet switching and the high end provides the full duplex digital data services at 155.52 and 622.08 Mbps or even higher speeds [181].

3.1.3.2 Information Super Highway

Information Super Highway is the network which combines Internet, Intranet and other networks for digital multimedia data transfer. The World Wide Web (WWW) gives a graphical, easy-to-navigate interface for looking at documents on the Internet using a unique address called a Uniform Resource Locator (URL) and a browser. The Web is fundamentally a system of requests and responses. The Internet Information Server listens for requests from users and responds typically in the form of a static HTML page, a dynamic HTML page, or a directory listing page (Fig. 3.8). Internet Information Server can provide intranet with the features like hypertext pages, client/server applications, and database access. Internet Information Server is scalable and can support a single-server site to large multi-server installations for Internet or Intranet. Sequential Query Language (SQL) database, or Remote Access Service (RAS) is used to provide dial-up access to the workgroup's resources from remote sites (Fig. 3.9).

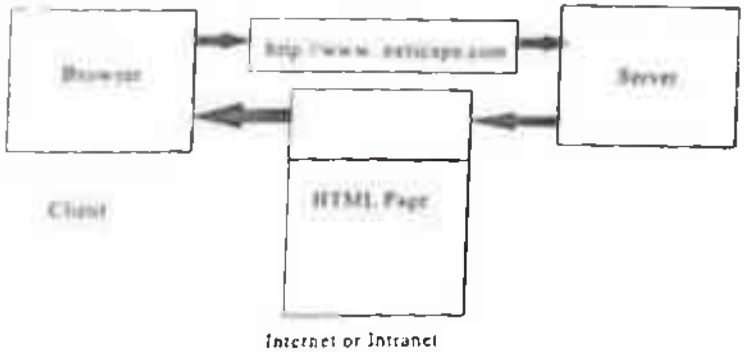


Fig. 3.8 Responce from Server

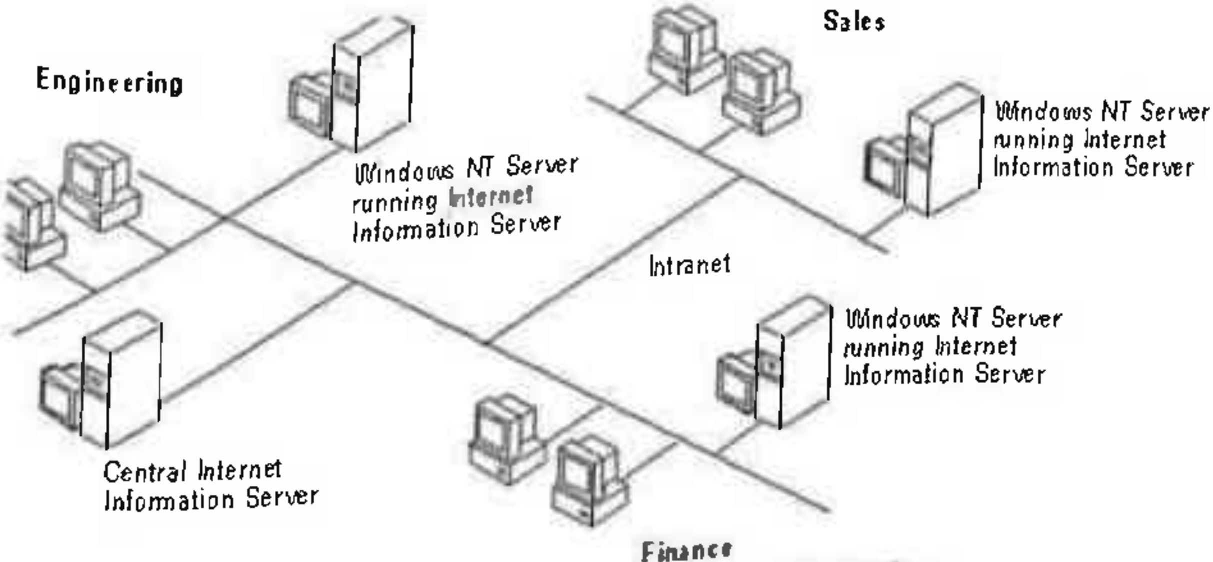


Fig. 3.9 A Combination of Internet and Intranet for Archives

3.1.3.2.1 Protocol for delivering audio /video on Internet

Internet uses TCP/IP protocol [182,183] for data delivery which is not efficient in handling continuous time based audio / video. The way data is transmitted across the Internet and the protocols used have direct bearing on the overall efficiency, performance and reliability of broadcast application. Flow control mechanism is used to achieve high performance continuous audio / video delivery. In a flow control mechanism, statistical and instantaneous information about network throughput, reliability measurement, bandwidth availability, receiver's current buffer size, packets received by receiver etc. are used to control the video transmission. Flow control is also used to embed security mechanism, such as copyright protection and encryption, into video transmission. Few of the protocols used for audio /video delivery are described below:

3.1.3.2.1.1 User Datagram Protocol (UDP)

UDP is a bandwidth-oriented streaming protocol without error correction. UDP transmits small packets at a high priority but does not guarantee packet delivery. A flow control mechanism is used to avoid the saturation of the network. UDP opts for broadcast efficiency at the risk of quality degradation and is best suited for audio-delivery [184].

3.1.3.2.1.2 Transmission Control Protocol (TCP)

TCP uses large packet size for delivery of high volume of data and uses flow control mechanism to ensure fair resource utilization. The guaranteed in-order packet delivery is ensured by re-transmitting of lost or scrambled packets by the server. However, the packets being larger (6 thirty two bit header + data makes a segment), in case of packet loss, the playback at receiver stops till the packet is received again. For continuous media applications, therefore, a different strategy is adopted. Instead of re-transmitting everything lost, only significant data viz. I-frames in MPEG scheme, is selected for re-transmission [185].

3.1.3.2.1.3 IP Multicasting

IP multicasting is ideal in situations like scheduled programming or live audio where many people are like to tune to the server simultaneously. In IP multicasting, a dynamic host group is created and IP datagrams are sent to all the members of the host group. In order to provide a reliable multicast service, the following mechanisms are employed.

a) Adaptive time-out with exponential back off : In this technique, the RTT (round trip time) for every datagram is measured, and the packets are re-transmitted in absence of acknowledgement from the receiver. In case no response is received within a predeifined time period, the receiver is taken off the subscription list. Exponential backoff identifies the strategy used for calculating time -outs for re-transmission.

b) Packet sequence numbering : This allows the listener to discard duplicate packets and take action to prevent what is known as sorcerer's apprentice syndrome (RFC 1123).

3.1.3.2.2 One-Way Virtual Broadband Network

The technology allows user to dial their Internet provider using low-speed telephone lines but receive the audio/video file over user's own satellite dish using Ku-band. The data is routed through an intermediate server using high speed lines (upto 400 kbps). The technology is able to provide "real time audio, video and multimedia file transfers" "to an unlimited number of locations in continuous feeds, scheduled regular transmissions or occasional, as needed, broadcasts". [186]

3.1.4 Software Issues

3.1.4.1 Information System

Information System is vital for efficient, effective and optimal use of broadcast archives. IS planning is perceived as a very important activity in an organization [187]. Some of the computer based systems on which IS for archives can be built, are described.

3.1.4.1.1 Data Base Management System (DBMS) based Systems.

This has already been described in section 2.3.3.

3.1.4.1.2 Expert System (ES)

The potential of Expert System for strategic management has been described by many authors [188,189,190]. Expert Systems have been extensively used in a variety of areas in Information Systems, especially in IS retrieval. ES's capabilities allow them to help user retrieve information in a more effective and efficient manner [191]. Expert Systems are programs that use interface techniques that involve formal reasoning normally performed by a human expert to solve problems in a specific area of knowledge. Expert systems can advise, diagnose, analyze and categorize using a previously defined knowledge base. The knowledge-base is a collection of rules and facts. ES's are developed either through the use of programming languages, such as PROLOG or LISP, or ES tools/shells, such as VP-EXPERT [192].

To use an expert system, user begins by specifying a goal. The system then attempts to solve this goal by asking a series of questions and using its internal knowledge.

3.1.4.1.3 Hypermedia Based System

Hypermedia is a way of representing and accessing information. It views the information space as a graph whose nodes store information. In a Hypermedia system, a hyperlink corresponding to the embedded pointers is marked. When a hyperlink is activated, the system extracts it's destination node from the hyperbase and presents it to the user with associated methods [193,194].

3.1.4.1.4 Object Oriented DBMS

The object oriented approach [195,196,197] has become popular in recent years. Using the object oriented approach, analysts model the system being investigated by identifying a set of objects in conjunction with attributes and methods that manipulate the object data or request services from other objects. Objects are grouped into classes, which have common properties. Classes are organized into hierarchies in which the subclasses inherit properties, including data definitions and methods. Interactions between objects are handled by means of message sending. All of the characteristics of the object-oriented methods make the approach more effective than the traditional method in Information System development [198,199].

3.1.5 Systems for deriving indices from images

One of the key features required in an video database is efficient indexing to enable fast access to the images in the database. Typically, indices derived from the image are used to search and retrieve the image(s) of interest. Recently, several image/video indexing techniques have been reported in the literature [200,201,202]. The first class of algorithms is based on descriptive keywords associated with the images. Rove et al. [203] have presented the design and implementation of a metadata database for video retrieval. A second class of algorithms is based on feature vectors derived from the images. For example Gong et al. have presented an image indexing technique where the indices are generated using image/subimage histograms [204]. The third class of algorithms is based on motion vectors. For example Lee et al. have presented a video indexing technique based on the motion representation for the track of a moving object[205]. Idris et al have described vector quantization (VQ) as a technique for image compression for video applications [206].

In VQ , a training set of representative images is decomposed into L-dimensional vectors. An iterative clustering algorithm such as the LBG algorithm is used to generate a codebook of size K codewords. The codebook is then made available at both the transmitter and the receiver. In the encoding process, the image to be compressed is decomposed into L- dimensional vectors. Using a nearest neighbor rule, each input vector is mapped onto the label of the closest codewords as shown in Figure 3.10. The labels of the codewords are used to represent the input image. Image reconstruction is implemented by a table look-up where the label is used as an address to a table containing the codewords.

Typically, adaptive techniques are employed to provide a good coding performance . Here, the codebook is adapted to reflect the statistics of the image being coded.

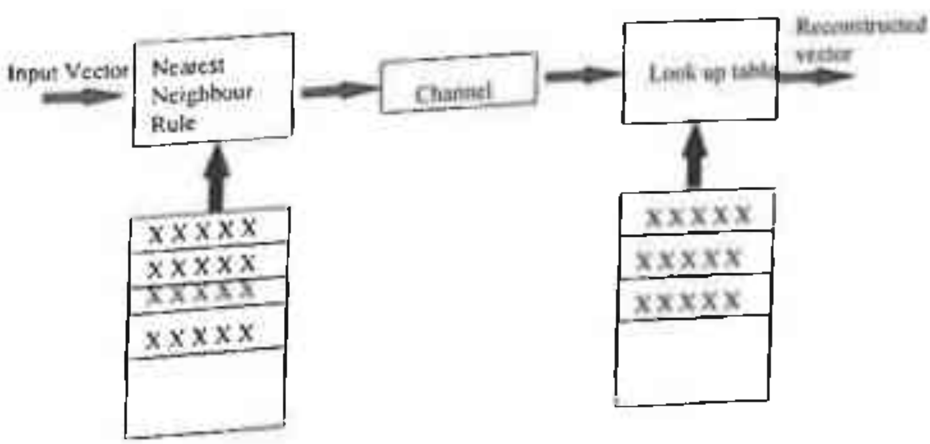


Fig. 3.10 Vector Quantization for image indexing

3.2 Technological Options for the Future Broadcast Archives

3.2.1 Analog Vs Digital

Digital format provides integrated media management for projects containing tens of thousands of media clips for advanced logging, tracking, browsing and archiving. It allows to share and track media across multiple projects for intelligent management of digital media based on its quality and content. Browsing of content, projects, clips, presets etc. becomes possible in digital domain. Content based retrieval using image browsing makes possible to detect an image out of a clip. Integrated search engine enables rapid property-based search of content. Content logging information provides an archival logging history supporting recapture of digital media based on archived logs. Protection from data loss with advanced crash recovery is possible.

Broadcast systems all over the world are getting digital. Harris Allied USA has already demonstrated all solid state digital automatic broadcast system [207]. All future systems being planned viz. DTH, ISDB, DBS etc. are based on MPEG-2 Digital system. Digital format also provides economic advantage in post production.

As such we recommend all future broadcast archives to be digital.

The implication of this recommendation is collection of the material in different formats and their conversion into digital form. This is undoubtedly a time consuming task since today's broadcast systems have a complex mix of analog production equipment, transmission equipment, and satellite connections which are not covered under a uniform, system-management umbrella because of the heterogeneity of the equipment and services. A Study Group on Broadcasting System in the Multimedia Age was set up in May 1994 in Japan for examining two major issues, (a) prospects for digitalization of the whole broadcasting system, and (b) measures for promoting Hi-Vision broadcasting. The group has recommended as below [208].

- Digitization of all the broadcast media so as to establish an information and communication infrastructure that is seamless between wired and wireless media and between broadcasting and telecommunication.
- Receipt of digital broadcasting images with a Hi-Vision receiving unit using an adapter.
- Introduction of digital broadcasting system using communication satellites for television reception immediately.
- Introduction of digital satellite broadcasting on 12 & 21GHz-band for television from the beginning of 2007.
- Terrestrial Radio and Television broadcasting to become digital latest by the first half of the years 2000-2010.

3.2.2 JPEG vs. MPEG for Archival Storage

In non-linear editing, frame access is required and therefore JPEG may be preferred over MPEG. This is because JPEG standard encodes and transmits individual frame as against the MPEG which uses a group of frames to determine the redundancy. In case of MPEG, few frames can altogether be dropped and it is not possible to recover them at the time of editing. MPEG may be useful where large amount of video information is required to be stored and retrieved without manipulation performed on it, such as video-on-demand. Applications like non-linear editing can take advantage of MPEG when the professional MPEG-2 standard with 4:2:2 profile is available in large scale [209]. The profile defines the colorspace resolution, and scalability of the bitstream. The 4:2:2 profile allows editing of video components.

Therefore, we recommend MPEG-2 for film or feature based contents and JPEG for scenes, effects etc. For audio, AC3 Dolby is recommended, since it has been accepted as the compression standard for DVB, DAB, ATV and HDTV.

As far as compression is concerned, it is necessary to map on appropriate compression technology to the application in mind, whether it is non-linear editing or video-on-demand or archival access on request. Interoperability and standardization shall be required to make the long term archival storage economical.

3.2.3 Storage and Disk Performance

The digitization of multimedia information viz. image, audio, video, produces a large set of bits called "object" or "blobs" (Binary Large Objects). The digitization of a movie, even after compression, may produce a blob of 3-4 GB. Image, audio and video compression technologies are used to minimize storage and distribution requirements. Table 3.4 gives the storage requirements for different multimedia data for broadcast archive.

Table 3.4
Storage requirements for multimedia information

Information	Storage size
1 page text	3KB
1 page graphics	20KB
1 page black/white scanned text	50KB (JPEG compression)
1 page color image	5MB (JPEGcompression)
1 minute audio clip	10MB (AC-3 compression)
1 minute video clip	30MB MPEG-2 compression'

A D1 signal of 270 Mbits per second can be compressed to 48 Mbit per second (6 Mbyte per second) using a JPEG CODEC for the quality to a level that is available from a digital betacam recorder. A satellite transponder is generally capable of handling data upto 30 Mbyte per second and, therefore one transponder could handle 5 TV channels along with sound embedded. However, as far as its storage is concerned the transfer rate of a SCSI (Small Computer System Interface) bus is 5 Mbyte per second. Fast SCSI and fast wide differential SCSI with 10 Mbyte per second and 20 Mbyte per second are available which could handle roughly upto two / four video channels simultaneously. The second aspect of a storage is a disk drive. Typically a media transfer rate of hard disk drive is 2-5 Mbyte/sec. and if request for playback comes from a number of users, there would be loss of performance known as "Hot Spots"[210]. This is not acceptable in the broadcasting world.

The solution to this is splitting the information of each video stream and writing them on multiple disk simultaneously known as Redundant Array of Inexpensive Disk (RAID).

For applications like video on demand, a video server with such a RAID is used. The details of a Video server have already been described in Section 3.1.2.

The new servers are capable of holding 1.6 terabytes of data and capable of supporting upto 35 channels [211]. A new serial interface known as a Fibre Channel (FC) supports a bandwidth of 800 Mbps for video servers. It allows connection of upto 126 devices spread over 10 kms. On the network side, the supported protocols are IP, AAL5 etc. [212]. On the other hand, the broadcasting centre - Canal+, using MPEG-2 and Disk-based Servers, has gone down to a bit rate of 2Mbps, an average compression ratio of 100:1 [213]. The server technology is maturing very fast.

As such, we recommend video servers for on-line storage and delivery of broadcast archives.

The **Full Motion System CD and Video Disc System Using Variable Rate** have recently been introduced. These **are also recommended for long time storage of archival material apart from the media servers**. However, the material stored on these could not be accessed on-demand.

Since the video server (also known as media server) is going to be the hub of on-line archives, it is worthwhile examining the impact of the server on future archives.

3.2.3.1 The impact of server technology

The impact of server technology on the video facility environment can be defined in terms of acquisition, distribution and archival storage.

3.2.3.1.1 Acquisition

Servers are somewhat inefficient in the area of acquisition due to the necessity of dubbing from tape before the video becomes usable. This is specially so because video and films are mostly analog. The servers employing concept of multiple simultaneous channels, allow using it as soon as recording begins. Multi-channel servers are faster than real-time dubbing since they process a number of source reels simultaneously on multiple record channels. Future acquisition formats which provide random access or faster than real-time dubbing will continue to enhance the use of servers, and the server can accommodate any foreseeable format. Servers are also capable of accepting direct satellite feeds and providing point to point transfer of video to another city or country in digital form.

3.2.3.1.2 Distribution

Compression has created a new problem for the distribution of video. Serial digital distribution requires the compressed signal to be decoded at the source. If the destination were a digital recorder or digital transmitter, it would be encoded again. This cascaded compression introduces a new form of generation loss.

To solve the distribution problem, the MPEG 4:2:2 standard, which allows higher bit rates, higher precision in the DCT coefficients, and less temporal compression is being recommended. This new compression standard will make it possible to cut streams together without decoding while maintaining high enough quality in the studio such that a downstream transmission encoder will not introduce artifacts from cascading. Without this standard, broadcasters would be left with numerous proprietary schemes which must be translated from one format to another. This translation process is time consuming and must be done off-line.

Distribution of compressed signals without generation losses will require a standard broadband distribution network. This will make it possible to interface to other video equipment, computer equipment and telecommunications equipment. Since both compression and networking standards are required for plug-and-play interoperability and they are both still being defined, an important consideration for a server is that provision should be made for upgrading or expanding to new compression formats and new network interface in the future. The server designed with modular network and compression interfaces can easily be upgraded.

3.2.3.1.3 Archiving

Archives needing large amounts of storage will best be served by a combination of disk and tape. It is difficult to dispute that, even with the tumbling cost of disk, tape will always remain an alternate medium of choice, especially where permanent storage is required. The main question is whether the tape portion of the storage should be video tape or data tape. To avoid generation losses when moving video to and from the server in systems where compression is being used, data tape is the better choice. Compressed images are best archived in the compressed data format to avoid multiple decode stages. Since compression reduces both data and the required bandwidth, it allows transfer rates many times faster than those in real-time transfer.

Data storage system component provides data tape drives which can transfer data at eleven Mbytes per second. Since video is approximately twenty two Mbytes per second, this means that video compressed to a ratio of 6:1 can be transferred at three times real-time. With its multiple simultaneous channel capability, the video server can provide simultaneous output as soon as a transfer is initiated. This can take as little as a few seconds from request to output which is primarily the time required for the robots to load a tape.

A key difference between archiving on data tape as opposed to video tape is that the data tape transport is completely reliant on the server to actually use the data. It is not possible to pop in a tape and view it without first transferring it to the server. This close relationship between the video server as on-line storage, and the data tape storage robot as near -line storage (Fig.3.11) lends itself to being viewed as a self-contained system with a hierarchy of storage.

The server coupled with the robotic vault affords dramatic reductions in labour as tape is virtually never handled. A common database of all stored media can provides applications an easily accessible view of what is available online in the server and what must be transferred in from the Vault .

3.2.4 Information Management

Guynes et al [214] have described that the critical success factors for data management includes integrity control, database recovery, maintaining database dictionary, etc. All these functions become difficult in case of distributed database over multiple locations. Further, the DBMS based archive management system has the disadvantages of the use of query languages by users. Users are reluctant to learn SQL or other languages.

Expert systems require decision making rules to reside in a knowledge base [215]. Expertise is hard to extract from humans, especially for highly unstructured, complex and wide domain problems. Also it is subject to errors due

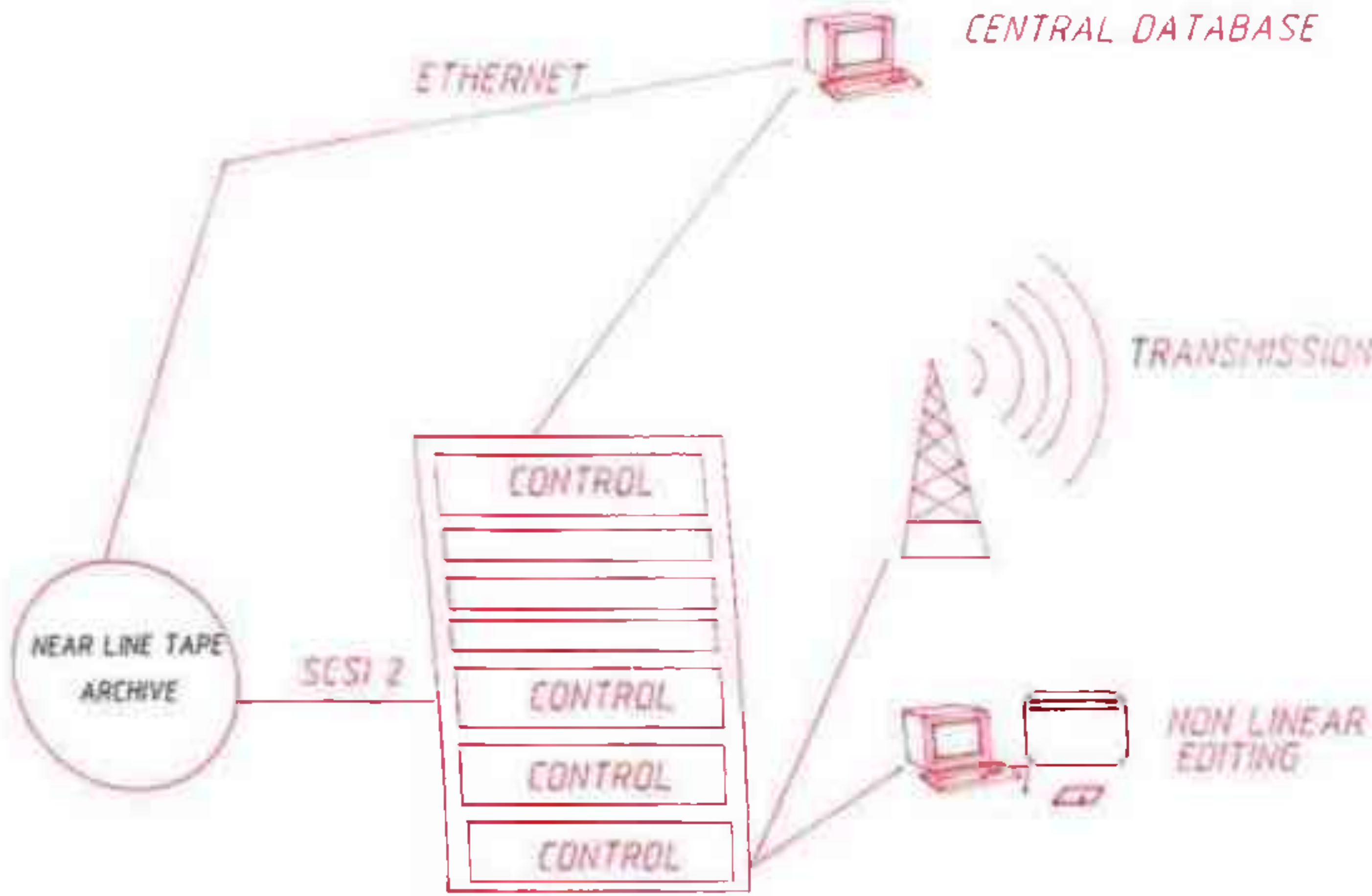


FIG. 3-11 NEAR LINE ARCHIVE

to perceptual and judgmental biases [216]. The Expert System needs to be programmed for heuristic solutions and integration with other technologies [217] viz *DSSs, neural networks, or robotics* [218,219] for many applications.

Object oriented approach, which is fast acquiring popularity, is still in a period of development. An object oriented data model has the problem of poor performance and divergent SQL standards [220]. It needs high skill in manipulating data and constructing query. The implementation is also costly.

The attitude of end users are very important consideration for development of an effective Information System [221]. Presently Producers see little or no connection between computer usage and the possibility of career progression. There is no reward to learning the computer skills. Therefore the IS should be user friendly and as simple as possible in use. There should be a common user interface throughout the organization so that the user don't need retraining on their transfers.

The broadcast archives need to be supported across a variety of network configurations, from stand-alone systems to local area networks (LANs), wide area networks (WANs), DVB/DAB networks or the Internet. The fast development of Internet and Intranet networks with common HTML interface shall have a great bearing on the IS for future broadcast archives. The HTML based browsers can be ideal solution for the multimedia data. This could be used on the internet as well as intranet.

As such, we recommend the future IS for archives as Hyperlinked based retrieval system with object oriented database for the multimedia metadata. The database search engine shall allow a variety of query.

3.2.5 Video Browsing

Future Multimedia Information Systems will be dominated by visual information specially in the case of broadcast archives. As such, there is an impending need to organize this visual information in a manner that is easily accessible from video and image databases. Browsing is an important feature to choose specific video segment or image of interest from visual databases. Two classes of browsing techniques are in vogue namely reduced quality and reduced resolution. These are essentially extensions of the browsing techniques developed for images. A baseline scalable video compression algorithm (NSERC IOR) using wavelet transform has been developed by MCI. This transform is a promising technique for representing images and video. The multi-resolution/multi-frequency feature of the wavelet transform is valuable in representing images and video as reduced quality and reduced resolution versions along with excellent compression performance.

Since the MPEG-2 standard was not originally developed to address the features of indexing and retrieval, extensions to the standard algorithms are being currently investigated. However, there are limitations to this approach as the DCT is not appropriate to implement the feature of indexing.

We recommend storage of video clips / photos as indices for search, as and where possible. As the scene detection algorithms mature, we also recommend auto segmentation of the video based on the scene detection.

3.2.6 CORBA Environment for Multimedia Applications

The simultaneous access to the same multimedia database by many users requires a series of software modules to allow users to interact on the same record, preserve the database integrity, transfer the information between files, set-up an alarm set for extreme cases, etc. The CORBA (Common Object Request Broker Architecture) standard and its implementations (Hyperdesk, Orbix, DOE, etc.) provide the mechanisms needed to browse and supervise the activities launched by each user, preserving at the same time the security of the operations. The combination of a CORBA like environment and the Java programming language enables the creation of downloadable applets, which are capable of accessing multiple, shared backend services located across the Internet. Java increases the value of the Internet by bringing application logic into the picture. Graphical User Interface (GUI) functionality can now be added to a multimedia application at the run-time. Integration with CORBA also offers the ability to perform semantically rich client/server operations. The real-time aspect can be obtained by running the CORBA software an a real-time platform.

CORBA implementations currently run on more than 20 operating systems from a single code base. Platforms include: Windows 95, Windows 3.1x, Windows NT, OS/2, Macintosh System 7.5, twelve different Unix systems, OpenVMS AXP and the real-time operating systems QNX and Lynx OS. Another touch of speed can be obtained by designing multi-thread multimedia servers. By its nature a multimedia CORBA agent can easily communicate in multiple media and playing the filtering agent role at the same time.

We recommend use of Java and GUI for enhancement of user friendliness.

3.2.7 Distribution System

The broadcast information superlane shall be undoubtedly dominated by the one-way conventional delivery system comprising of terrestrial transmitters, DSS, DTH etc. However these will get greatly supplemented by new interactive delivery systems of Internet broadcasting, interactive DTH in Ka band and broadband ATM or SDH/SONET. These modes of broadcasting have already been described earlier in this thesis. What needs to be emphasized here is the recent developments. In case of Internet, there are more than 200 radio and 45 TV broadcast stations already on the net [222]. In the case of DTH, 214 broadcasters have lodged their demand with ITU for registration of use of frequencies in Ka band (17.7 GHz to 20 GHz) and orbital slots. This rise in demand is because of the fact that Ka band is capable of providing a return link with a one watt transmitter and 60 cm dish with the viewer, inspite of the fact that rain attenuation is severe at these frequencies. Research is ongoing to use high elevation (400) satellite so that signals come close to paralleling the rain than traveling against it [223]. Interoperability of the Grand Alliance HDTV system with the ATM Networks is already being established [224].

We recommend use of a mix of LAN, WAN, Digital Distribution and Broadband network and Internet for distribution of holdings in the archive.

The mix shall depend upon the type of organization, it's location, number of stations, the type of country, the placement of users, etc.

Chapter

4

System Design for On-line Broadcast Archives

4.1 Introduction

This Chapter will describe an Information System for On-Line Broadcast Archives Management System (OLBAMS). This will include the system architecture, design details of a prototype developed and the quality tests conducted as a part of the research work. In Chapter-3, the future archive was recommended to be digital, server based and using a variety of conventional and broadband networks. The present system is developed on the basis of these recommendations. The OLBAMS is capable of delivering a large variety of video / audio material - ranging from history, science, and technology to natural history, world cultures, music and fine arts etc. from digital multimedia broadcast archive. The archive is designed to deliver content as well as information about the content on-line using a variety of network configurations viz. conventional broadcast networks, local area networks (LANs), wide area networks (WANs), or the Internet /Intranet. While developing this archive, the technological advancement in the field of broadcasting, computer and communication described in earlier chapters, has been kept in mind. Certain terminology used in this chapter are described below.

4.2 Terminology

4.2.1 Network-centric computing

Network -centric computing is the third generation of computing model. In 80's, computer applications were developed on Main-Frame host computers which used to provide access to information through "dumb-slave terminals". This host-centric model evolved to the second generation model with the advent of client/server technology. Application function is split between the client desktop and the server system in this model. Network-centric computing describes applications that rely heavily on function within a network of computers that work together to solve a problem, rather than a single host processor or a client/server pair.

4.2.2 Triangle architecture

The client (producer /users) requests information from the archive server, which manages the index and search support data. The archive servers direct the object servers (video or media), which manage the digitized content, to deliver the object directly to the requesting client.

4.2.3 Server

The server is basically the networked computer . Two type of servers shall be used. These are video servers and the data servers. The video servers are also called media or object servers and these would store the media data or media files only. The metadata along with the search and access software including OODBS, page designing software etc. shall reside on the data server.

4.2.4 Parametric search

Using an index of known characteristics to find an object is known as parametric search.

4.2.5 Content-based search

When executing a search, the desired information is retrieved on the basis of ideas or concepts contained in documents, not on the occurrence of specific search terms.

4.3 Function of OLBAMS

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 collecting the material and converting the existing material / catalogues into digital form. ISM is responsible for putting it on-line and providing all computer facilities for on-line access. TM is responsible for network operations for the delivery. The FM is responsible for accounting functions. These functions are performed with the help of various equipment or sub-systems. The functions and the sub-systems of the OLBAMS are depicted in Fig. 4.1.

4.4 System Architecture

In recent years object-oriented approach has received attention from the computer and information system industries [225]. Using the object-oriented approach, analysts model the system being investigated 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 methods such as Task System Design[226], GOMS[227] and Task-Analysis for Knowledge Description[228] 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 [229] and the same shall be used in this paper to analyze the task and development of a model.

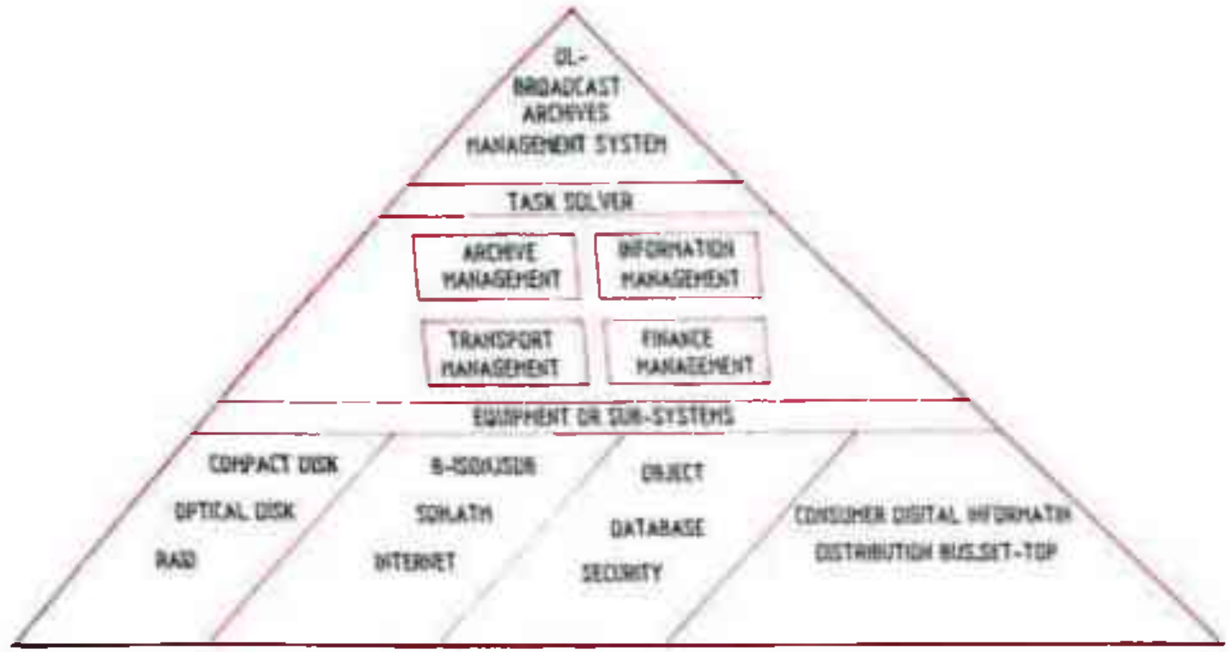


FIG. 4.1 Functions of On-line Broadcast Archives Management System

4.4.1 Description of Task Solvers

The On-Line Broadcast Archive Management System has four task solvers which could be represented as objects with goals as attributes. The administration of Broadcast Archives Management is realized by the help of four task solvers viz. AM, ISM, TM and FM who have pre-defined goals.

4.4.1.1 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, realization of money for the services provided etc.

4.4.1.1.1 The goal of Archives Management (AM) task solver

The main functions of the AM task solver are described below:

- Collecting the material in analog /digital format.
- Converting the existing analog material into digital form (encoding and compressing).
- Storing it on a Direct Access Storage Device (DASD) such as Compact Disk (CD), Optical Disk, (OD), video disk servers (RAID)
- Providing a catalogue of each recording in two parts viz. audio/video (A/V) clips in a digital form and information (Minimum Data List) viz. Title, Singer, Composer, Theme, Category etc. as per a format. In certain cases, graphics for photos /album etc. is also required to be stored in compressed form.

4.4.1.1.2 The goal of Information System Management (ISM) task solver

The main functions of the ISM task solvers are described below:

- To provide an Hyperlink 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.

4.4.1.1.3 The goal of Transport Management (TM) task solver

The main function of the TM task solvers are described below:

- To provide system for delivery which could be a mix of existing broadcast transmission systems, Asynchronous Transport Mode (ATM), Synchronous Digital Hierarchy (SDH), Integrated Services Digital Broadcasting (ISDB), BISDN, Internet etc. for on-line information access / delivery of full video/audio.

4.4.1.1.4 The goal of Finance Management (FM) task solver

The main function of the FM task solvers are described below:

- Rights Management
- 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. 4.2.

4.4.2 Description of the processes

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 design details of various modules are described in the next section.

4.5 Design Details

4.5.1 Material Transfer and storage

The Joint Photographic Experts Group (JPEG) [230] and the Moving Picture Expert Group (MPEG) have developed compression standards for still images, and full motion pictures. The MPEG-2 standard has been extended to encompass HDTV [231]. MPEG-2 is capable of providing varying quality from VHS (1.5 Mbps) to HDTV (20 Mbps). It can serve both the producers as well as consumers. Therefore, the recommended coding system for video is MPEG-2, and multiplexing is also MPEG-2 (DVB and ATV standard), for source coding (voice coding system), both MPEG-2 audio and Dolby AC-3 can be used. The

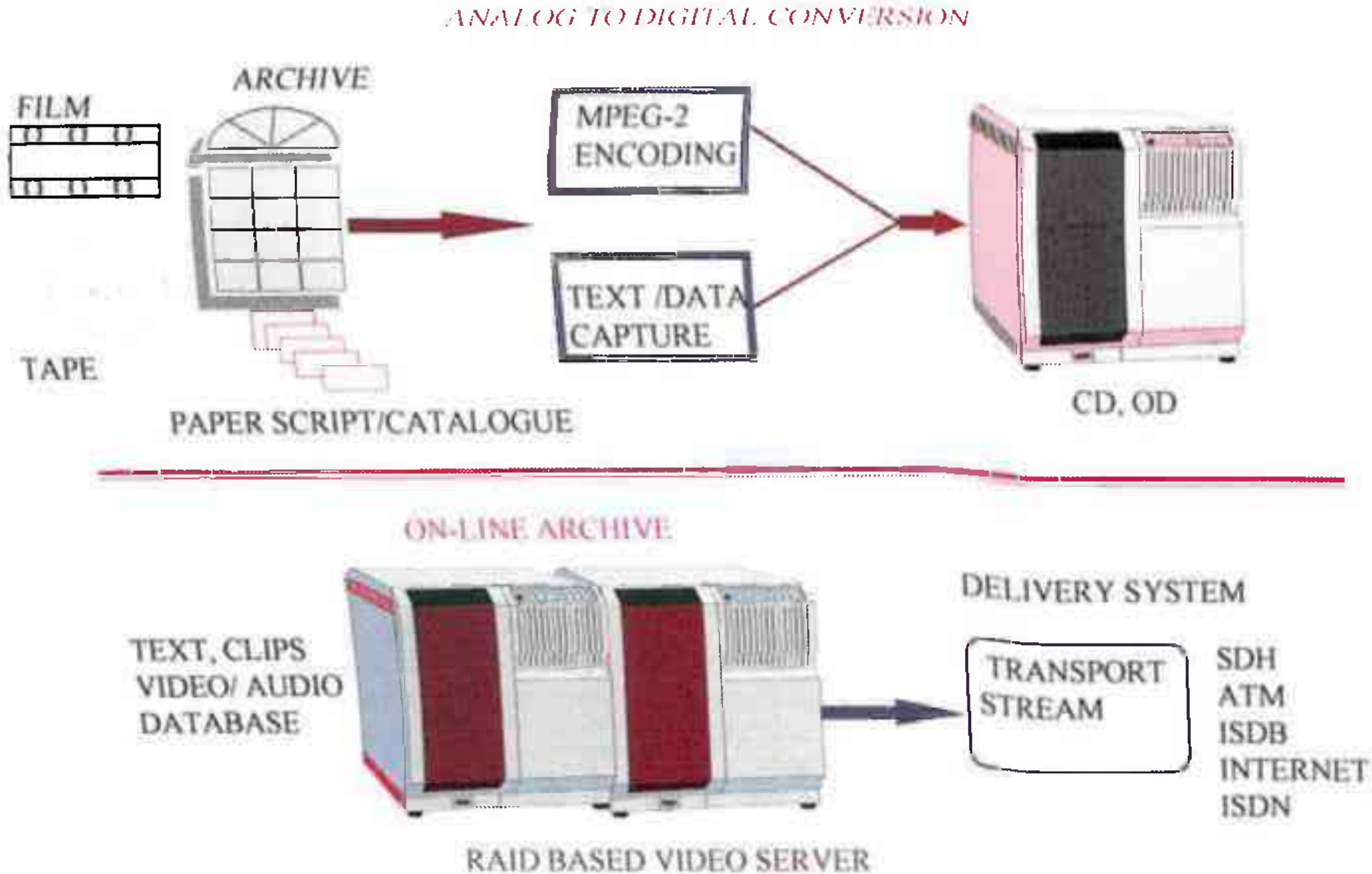


Fig. 4.2 Conceptual Overview of the Model

photos, albums etc. can be coded using JPEG standard. However, as we have pointed in Chapter 3, wherever, non-linear editing is expected in future, *the video shall have to be stored in the JPEG compressed form.*

Using above coding , the analogue disk/tape is transformed in the digital form. Signal processing allows enhancement of quality, where required. The suitable clippings are also stored in digital form viz. .AVI, .FLI etc.

Holdings do not have to be necessarily available online, but most scenarios assume that they are. These holdings can be maintained on servers that support attachment of direct access storage devices and a range of optical storage devices. A robotic system can move these devices to the servers through computer commands. Transparent hierarchical storage management can automatically move seldom used holdings to more cost-effective secondary storage, such as optical storage.

.In post-production, the video server allows non-linear editing to be brought into the on-line suite with the highest possible quality. (Non-linear took on new meaning when the term was taken from film editing and applied to random access disk-based editing. As bandwidths in disk-based recording products have increased, non-linear editing has become common.) As many channels as are required for layering or effects can be allocated to an edit suite and all operate in real-time to provide CCIR-601 quality. Multiple source reels can be loaded simultaneously to achieve faster than real-time acquisition. Loading and dubbing can be done without interrupting edits in progress which maximizes the use of edit suites. By providing a pool of channels and disk storage media that can be dynamically assigned to edits as required, the server becomes a hub.

For broadcast, programs which provide reliable multi-channel output for on-air commercial insertion are available. One program allows server to complement a traditional cart machine by providing automatic downloading of spots as required for commercial breaks, another allows to replace it entirely for a tapeless on-air operation and delay management system.

The Information System and the collections can reside on the same system or different systems. Collections can be added to the archives at any time. However for bigger archive, the holdings are to be stored on a special media server. This will allow a digital archive to be configured to meet a wide range of storage and performance requirements. A digital archive can scale from a single workstation, to a LAN, to an organization-wide solution, and to global interconnections via internet or digital delivery systems (DDS) with millions of holdings with petabytes (10^{15}) of data. Video disk servers for video-on-line which can serve MPEG-2 video using 4:2:2 Studio Profile compression for non-linear playback are already available.

An illustrative object for this task solver is shown in Fig. 4.3 The system can be made completely computer controlled with functions such as load, rewind, play, record etc. being performed through computer instructions. The media server is designed to work efficiently so that the actual digitized information in the collection is accessed only when requested by the user.

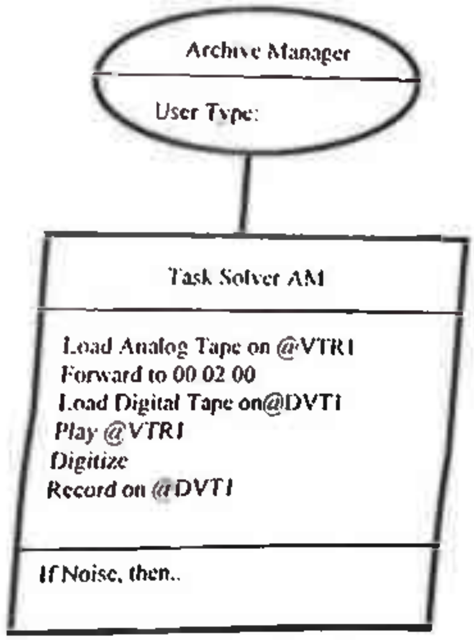


Fig. 4.3 Object for Archive Manager

4.5.2 Information system

The obvious candidates for the archives are Minimum Data List (Metadata), audio/video (A/V) clips, audio/video contents 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 through a browsing or a 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 logical view of the multimedia data stored in the information-base is shown in Fig. 4.4. The darken structures and text represent the video /audio data which are 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 authorization to access the full video.

4.5.2.1 Design details of H-AIRS

A system design for H-AIRS is given in Fig. 4.5. The Information-base consists of schema object and multilevel 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[232]. 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. For stream delivery, such as for on-demand video or audio, a client player method is invoked by the client application using the object handle returned in the search results. The handle is provided to the Multimedia resource manager for streaming from the collection to the destination devices. The presentation manager transforms the query in appropriate form.

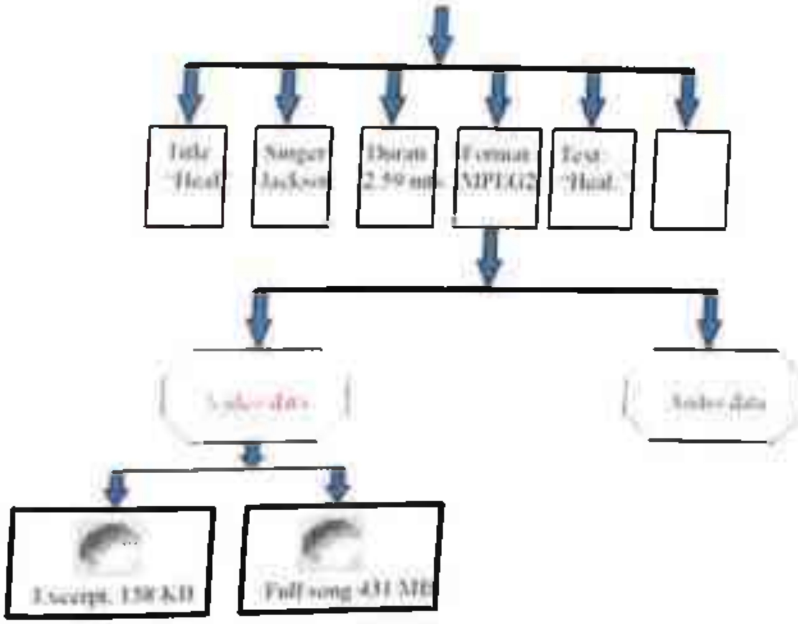


Fig. 4.4 A Logical View of multimedia object

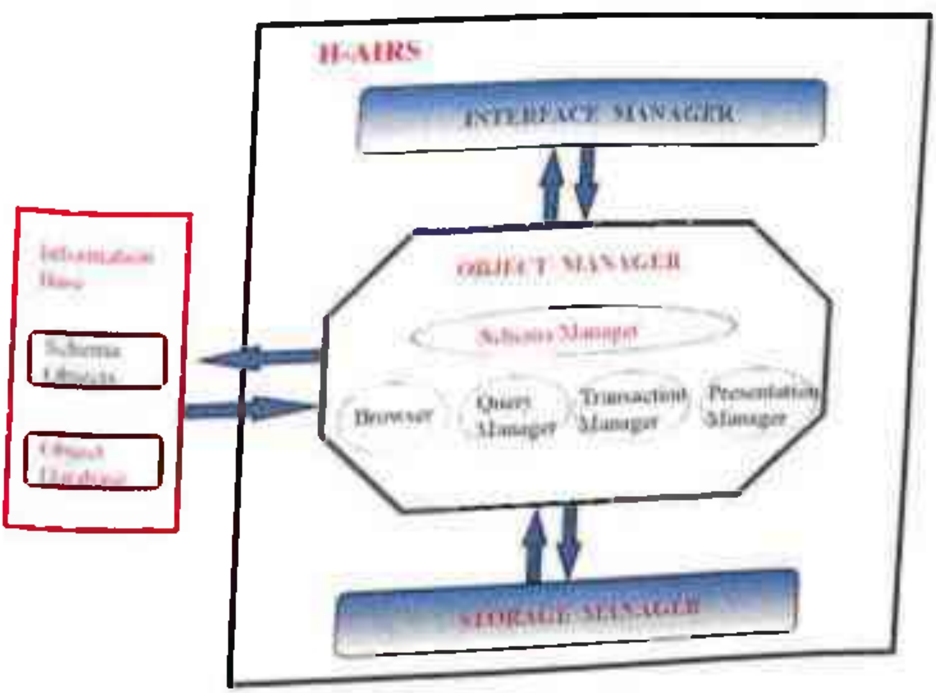


Fig. 4.5 Design details of H-AIRS

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 via various type of links. There are three types of nodes. Basic nodes store multimedia object for executing certain procedures. Organizational nodes are links or meta nodes. Inferential nodes are meant for intelligent information retrieval and are basically the rule nodes[233]. 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.

4.5.2.2 Information Retrieving, browsing and updates

The best search methods depend upon the type and size of the data and the user's objectives. Thus, we propose a mix of search technologies to provide the widest possible choice of search methods.

The simplest possible search is through hypermedia nodes. Text search includes a free-text query facility that allows users to express queries in a natural style. The result of a text search is a list of "scripts" sorted by highest probability of relevance. Probabilistic formulae are used to compute the rankings. Textual analysis of words as well as concept-based text retrieval are also possible. Clustering techniques organize the results of a search so that holdings with similar content are grouped together for easier selection. Abstracting reduces the search results to its main points, so that the user does not have to view all of the text to locate desired information. Query by image allows a collection of images to be searched on the basis of colors, shapes, textures, and their positions within *the image. Queries can be based on the properties of an outlined object in the* image, or they can be based on the entire image. For example, the query can be based on the car in a picture, or it can be based on the entire picture. The query parameters can be specified visually, for example, by selecting a color from one image to search for other images with the same color. Search results can be refined with subsequent queries to narrow down the results. Results are returned with a relevance ranking based on closeness to the specified parameter. Video indexing techniques detects properties such as scene changes and other video metrics. These techniques allow searching video streams, as well as indexing to particular scenes in a video. An agent which is a goal-oriented autonomous intelligent software module using JAWA is able to download the programme of interest with minimal supervision/intervention from the user.

The techniques used in the present architecture and the prototype model is described below:

4.5.2.2.1 Search through Hypermedia node

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 unauthorized 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.

4.5.2.2.2 Video Indexing and Browsing

Multimedia applications involve vast amounts of visual data in the form of video libraries and image catalogues which have to be indexed, stored, browsed and transmitted. Access to the stored visual information over networks such as ATM requires features including indexing, browsing, etc. to allow the users to select and view the specific video segment from a remote visual database. To enable efficient retrieval of the visual data, (i) appropriate indices for each video segment/sequences are generated and stored along with the visual information, (ii) an user interface is designed to facilitate browsing and choosing the information of interest. In addition, since most of the visual information is expected to be stored and transmitted in the compressed form, high-performance algorithms for joint compression and indexing have been explored. For this purpose, key-frames represented by properties of color, texture, shape and edge features, are retrieved from the video database systems [234,235,236].

Colour has excellent discrimination power in image retrieval since it is very rare that two images of totally different objects have similar colours [237]. The basic representation of the colour of a video frame is a histogram of the distribution of colour components. Average brightness, colour moments (including mean), dominant colour are also used for shot detection. If compressed data are used, these features are calculated from DCT coefficients of video frames.

A histogram of the distribution of colour intensities is a quantitative representation, especially useful for textured images which are not well served by segmentation techniques. Also, colour histograms are invariant under translation and rotation about the view axis and change only slowly under change of angle of view, change in scale, and occlusion [237]. Munsell space defines colour histograms close to human perception of colours [238]. QBIC quantizes the colour space into 64 "super-cells" using a standard minimum sum of squares clustering algorithm [234]. A 64-bin colour histogram is then calculated for each key-frame where each bin is assigned the normalized count of the number of pixels that fall in its corresponding supercell.

The distance between two colour histograms, I and Q, each consisting of N bins, is quantified by the following matrix :

$$D^2_{h}(I,Q) = \sum_{i}^{N}\sum_{j}^{N} \alpha_{ij} (I_i - Q_i)(I_j - Q_j) \qquad (1)$$

where the matrix α_{ij} represents the similarity between the colours corresponding to bins i and j, respectively. This matrix needs to be determined from human visual perception studies, and are derived using the method described by Gorkani [239]. It may be seen that if α_{ij} is the identity matrix, then this measure becomes Euclidean distance.

Because a probability distribution is uniquely characterized by its moments Rowe advocates representation of a color distribution by its first three moments [240]:

$$\mu_i = (1/N) \sum_{j=1}^{N} P_{ij} \qquad (2)$$

$$\sigma_i = [(1/N) \sum_{j=1}^{N} (p_{ij} - \mu_i)^2]^{1/2} \qquad (3)$$

$$s_i = [(1/N) \sum_{j=1}^{N} (p_{ij} - \mu_i)^3]^{1/3} \qquad (4)$$

where p_{ij} is the value of the i-th color component of the j-th image pixel. The first order moment defines the average intensity of each color component; the second and third moments, respectively, define the variance and skewness.

Using these three moments, distance may be computed as follows :

$$D_{mom}(I,Q) = \sum_{i=1}^{r} \{ w_{i1} | \mu_i(I) - \mu_i(Q) | + w_{i2} | \sigma_i(I) - \sigma_i(Q) | + w_{i3} | s_i(I) - s_i(Q) | \} \qquad (5)$$

where r is the number of color components and the w_i (1- 3) weight the contributions of the different moments for each color component. With small set of moments, it is possible for two qualitatively different color images to have a

D_{mom} value of 0. Nevertheless, experimental evidence has shown that this measure is more robust in matching colour images than colour histograms.

In most images, a small number of colour ranges capture the majority of pixels. These colours are used to construct an approximate representation of colour distribution. These dominant colours can be easily identified from colour histograms of key-frames. Only a few dominant colors will not degrade the performance of color image matching [236,237].

Motion is the major indicator of content change. Dominant motion components resulting from camera operations and large moving objects are the most important source of information for video parsing. For example, a zoom shot is usually best abstracted by three frames - the first, the last, and one in the middle. When MPEG video is used, motion vectors from B and P frames can be directly extracted for motion analysis.

The key-frame extraction process is also integrated with the processes of segmentation. Each time a new shot is identified, the key-frame extraction process is invoked, using parameters already computed during segmentation. Certain heuristics are also applied, such as the decision to use the first frame of every shot as a key-frame. The default is that at least two key-frames are selected for each shot; and, in the simplest case, they could be the first and last frames of the shot. The process is faster with compressed video data, and real time extraction can be achieved.

Texture is an important property of image, since textural information can be conveyed as readily with gray-level images as it can in colour. Nevertheless, there is an extremely wide variety of opinion concerned with just what texture is and how it may be quantitatively represented [241]. Among all these alternatives two models which are both popular and effective in image retrieval are: Tamura features [242] and the Simultaneous Autoregressive (SAR) model [243]. The Tamura features comprise of coarseness, contrast, and directionality, which are introduced as quantification of psychological attributes. Coarseness is a measure of the granularity of the texture. It is derived from moving averages computed over windows of different sizes; one of these sizes gives an optimum fit in both the horizontal and vertical directions and is used to calculate the coarseness metric. The quantification of contrast is based on the statistical distribution of pixel intensities [242]. Directionality is computed from distributions of magnitude and direction of gradient at all pixels. SAR model provides a description of each pixel in terms of its neighboring pixels for an image of gray-level pixels. For an MxM textured image, the intensity of a pixel at position s is given by

$$\delta(s) = \mu + \sum_{r=D} \delta(r)\, \delta(s + r) + e(s) \qquad \text{------(6)}$$

where, μ is a bias value which depends on the mean gray-level of the entire image; δ is a set of model parameters which characterize the dependence of pixel s on its neighbors r; D is the set of neighbors; e(s) is an independent Gaussian random variable with zero mean whose variance models the noise level. The effectiveness of the SAR model depends on the quality of estimates for δ and variance, which are usually determined by either least squares or *maximum likelihood estimation.*

For either model texture is represented quantitatively as a feature vector X. For the SAR model the distance between two such vectors is given by the Mahalanobis function:

$$D_{Mahal} = |(X^1 - X^2)^{-T} |C^{-1} |(X^1 - X^2)| \quad \text{------------(7)}$$

C is the covariance matrix which models pairwise relationships among the individual model features. Because the Tamura features are almost uncorrelated, the following simplified Mahalanobis function may be used instead:

$$D_{simp} = \sum_{i=1}^{j} \frac{|(X_i^1 - X_i^2)^{-T}}{d_i} \quad \text{------------(8)}$$

Edges derived from an image using a technique such as a Sobel filter, provide good cue for content: humans can easily identify some objects from their edge maps. Two images are then compared by calculating a correlation between their edge maps [244]. Key frames are retrieved based on such a similarity measure. However, these comparisons are limited by their dependency on image resolution, size, and orientation.

Dominant objects in key-frames represent important semantic content and are best represented by their shapes, if they can be identified by either automatic or semi-automatic spatial segmentation algorithms. In comparing similarity between shapes, cumulative turning angles are used, because they provide a measure closer to human perception of shapes than algebraic moments or parametenc curves [245]. This metric also provides: 1) invariance under translation, rotation and scaling, 2) invariance with respect to convex and non-convex polygons, and 3) relatively easy computation.

After partitioning and abstraction, the next step is to identify and compute representation primitives, based on which the content shot are indexed, compared, and classified. Ideally these are semantic primitives that a user can employ to define "interesting" or "significant" events. Query by visual templates is based on the assumption that a user often wants to retrieve key-frame images which consist of some known color patterns, such as a sunny sky, sea, beach, lawn, or forest. These pre-defined templates are stored and displayed as colour texture maps and can be selected by the user to form a query.

Recently, the International Standards Organization (ISO) has started the activity on the MPEG-4 standard for low bit rate video compression. In addition to MPEG-4 serving as a compression standard for applications such as wireless video communications, it is also expected to address the emerging issues of indexing and retrieval.

Browsing the video / audio databases stored in remote locations, requires a powerful user interface to enable producers and users to access the reference material. The video browser not only represents the visual information but also provides fast access to the video segment or image of interest. The Video Browser lets the user query and view a video database based on scene content.

4.5.2.2.3 Updation

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.

4.5.2.2.4 Access Control

Network computing make information widely available. With data so widely available, broadcasters need control over use of their property. The IS should be able to prevent unauthorized use or redistribution of their materials. Because holdings are made up of embedded parts, royalty payment, rights protection, and usage fees may apply.

Archive holdings must be protected not only in the video server, but also after they have been transmitted. Therefore, servers must have programs which may prevent or report unauthorized uses. These trusted programs can also be the part of the browsers. Rights management compliant browsers can be downloaded to user workstations. Solutions to intellectual property rights management programs must cater to following areas:

• Identification and authentication

Identification and authentication of users is important with respect to individual access to the information, especially when payment, whether by subscription, membership, or fee-based, is required. Equally important, users want to be sure that the materials they receive are authentic. The authentication is also required in respect of producers who may need to download the holdings for producing new programmes. The control may be through multi-level password. There may be certain programmes intended for making available widely to the public. After all, broadcasting in many countries are free. For this access may be without any password.

• Protection

Reasonable techniques to avoid misuse of materials and loss of royalties must be employed. For this purpose, license agreements between broadcasters and subscribers, must be in place before the holding is made available to users. These agreements provide the legal language defining rules for storage, use, and access to the digitized information, as well as royalties or other compensation to the rights holder. Licensing agreements, rights, and royalties are often individually negotiated, and can be different depending on the distribution medium and the type of users. Also, the rights to distribute or to use the intellectual property might be good only for a specific time period.

• Encryption

Encryption and key management techniques can be used to protect holdings [246]. Some encryption techniques include scrambling the data itself and using a special envelope, or Cryptolope. Encryption is important for high value, or confidential, assets.

• Conditional Access

It is essential to control the access of broadcast signals for services like Pay-TV and Pay-channels. A complete access control system includes three main functions: the scrambling /descrambling function, the entitlement checking function and the entitlement management function. The fastest and easiest way to scramble digital data, is to add modulo 2 data to a pseudo random binary sequence (PRBS) generated by a PRBS generator. Scrambling can be applied commonly or separately to the different components of the TV programme viz. Video, sound and data, to make these components unintelligible. A control word known by authorized scrambler and descrambler is used. For example, the access control system for 34-45 Mbps TV codecs use a 64 bit control word that is renewed every 8.2 sec.

The rights and associated keys needed to descramble a programme are called entitlements. This is done by broadcasting the control words and the conditions required to access the programme. Upon reception of an ECM (Entitlement Checking Message), the receiver sends the encrypted control word and the access conditions to the security device- usually a smart card- which checks their origin and the integrity before decrypting the control word and sending it to the descrambler if the customer is authorised to watch the programme. The entitlement management messages (EMM) are validity period, consumable units, geographical location etc. [247].

4.5.3 Transport system

Networking is needed to provide:

- connectivity between multiple server,
- wide area networking for global material movement / delivery,
- redundancy configurations and
- system expandability.

There are two types of networking. An "inter-system network' can connect multiple video servers together. A 'wide area network' (WAN) provides global connectivity, allowing data to be moved across vast geographic distances. Currently, FDDI running at 100Mbps is used to interconnect multiple server. High speed networks such as Fibre channel running at 1 Gbps are now available these have increased this capability significantly. For wide area networking, an ATM interface at 155 Mbps is an existing standard for non-real time transfer between servers.

Network interfaces connecting video servers provide a total, higher channel solution and allow data transfer across wide distances. In addition, with standard network interface, new video server can be added to a facility with complete leverage of the existing video server system via the network interface. This is similar today to having different generations of PC platforms running on the same LAN. The benefit of the new system can be utilized without replacing the old system. As time continues, one can expect that the video server will evolve, but through a standard networking interface it is possible to maintain stability and the advantages of new capability without removing existing system.

The digital multimedia can be delivered through terrestrial, cable or satellite. 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[248]. 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 gateways. The archive is accessed through satellite, terrestrial and cable networks on this CDID bus.

4.5.4 Finance management

There can be various type of services viz. free-to-air broadcasting, subscription service and on-line information service. The OLBAMS is able to monitor the usage of holdings in real time, and in detail, so that proper billing can be done. It also maintains usage data on each part of a holding, and provides these usage reports to billing applications or other business processes.

4.6 Prototype Development

The core of the system is the *Broadcast (Media) Server* that interfaces with an http (Web) Server [249]. There can be remote audio/video databases with multiple Servers. The processes involved are mentioned below:

4.6.1 Media File Digitization

Since many broadcast system are still analog based, the audio and video source are digitized using a standard sound card, a video capture card or both. Compression being a garbage-in, garbage out proposition, highest quality signal to the encoder is ensured.

4.6.2 Media File Encoding

The data compression to enable delivery over broadcast network, ATM, BISDN as well as real time delivery over connections as slow as 14.4. kB/s (9.6. kB/s for audio) is achieved by encoding. For delivery over broadcast network, the MPEG-2 encoding is used. For real-time delivery over Internet, encoder software uses lossy compression algorithms to squeeze data into compressed format. The title, author and copyright information is also embedded at this stage to be read by the player. For audio coding, real audio encoder was used.

4.6.3 Embedding Multimedia into a Web Page

A pointer placed into standard HTML tag in the web page links to a token file on the media server. This token file contains type and location data about the media file itself.

4.6.4 Integration Of Multimedia Files into the Server Environment

The server stores meta-data about the holdings in the archive, as well as the holdings themselves. The meta-data are the index and search criteria (attributes) for the holdings in the collection. This includes the content-based search criteria. The library server uses object database technology to manage the index and search criteria. The web server recognizes the multimedia formats by registering the file's extension with the server as a MIME (Multi-purpose Internet Mail Extension) type. The server also contains information such as Protocol Port, maximum connections, connection time-out, security etc. Server push feature allows delivery of multimedia content without requiring the customer to request or "pull" the information. With this mechanism, the server sends down a chunk of data. The browser displays them leaving the connection open to receive more data for a fixed time or until the client interrupts the connection.

The MIME (Multipurpose Internet Mail Extension) type used for the server push is called "multipart/x-mixed-replace". The "replace" indicates that each new data block will cause the previous data block to be replaced. A sample description of a CGI (Common Gateway Interface) [250] program that uses this technique is described in Table 4.1.

Table 4.1 CGI Program for Server Push

```
print "Content-type: multipart/x-mixed-replace; boundary=--ThisRandomString--"
print "---ThisRandomString---"
while true {
print "Content-type: image/jpg"
print <image>
print "—ThisRandomString---"
}
```

4.7 A Session

The system provides an opening Menu which is a HTML Page as shown in Fig. 4.6. This menu provides a general idea about the service. The first time user has the option to directly go to the system requirement menu or the programme menu by clicking on the JAWA applet. If he selects the programme menu, he gets new page (Fig. 4.6.1). This page segregates the producers and the viewer/listener. The listener is told about the subscription services and taken to a new page (Fig. 4.6.1.1) where he has two search options viz. by query by form or query by video browser. If he chooses option query by form, he gets the screen 4.6.1.1.1. else screen 4.6.1.1.2

Fig. 4.6.1.1 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 unauthorized user will not get any information if he clicks on these nodes. An authorized 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. Alternatively the search can be done by video browser.

The query by video browser takes to screen 4.6.1.1.2. The basic VB interface consists of four screens: Category Screen, Video Shelf Screen, Query Shelf Screen and Text-output screen. The category screen presents to the user a predefined set from which to choose movies. This is the first screen presented to the user. Hindi Film, Sports, Horror, etc. are examples of the categories (Fig. 4.6.1.1.2). When the user queries for a certain category, the system presents a shelf containing videos available in the specified category (Fig 4.6.1.1.2.1). The user can then choose a video from this shelf. If the user is not happy with the choices presented, a query can be formulated via the query interface. The user can customize a query by specifying specific movie attributes of the desired movie (Fig. 4.6.1.1.2.2). Director, Actor, Producer, etc. are examples of attributes that can be specified by the user to build a query. When the user builds a query, all videos that conform to the query are displayed on a Text-output screen. (Fig. 4.6.1.1.2.3) The user can use this screen to generate a summary and look at a poster of the video.

After this selection he gets a new screen giving details of movie (Fig. 4.7) and by clicking the object he can watch or download the digital file

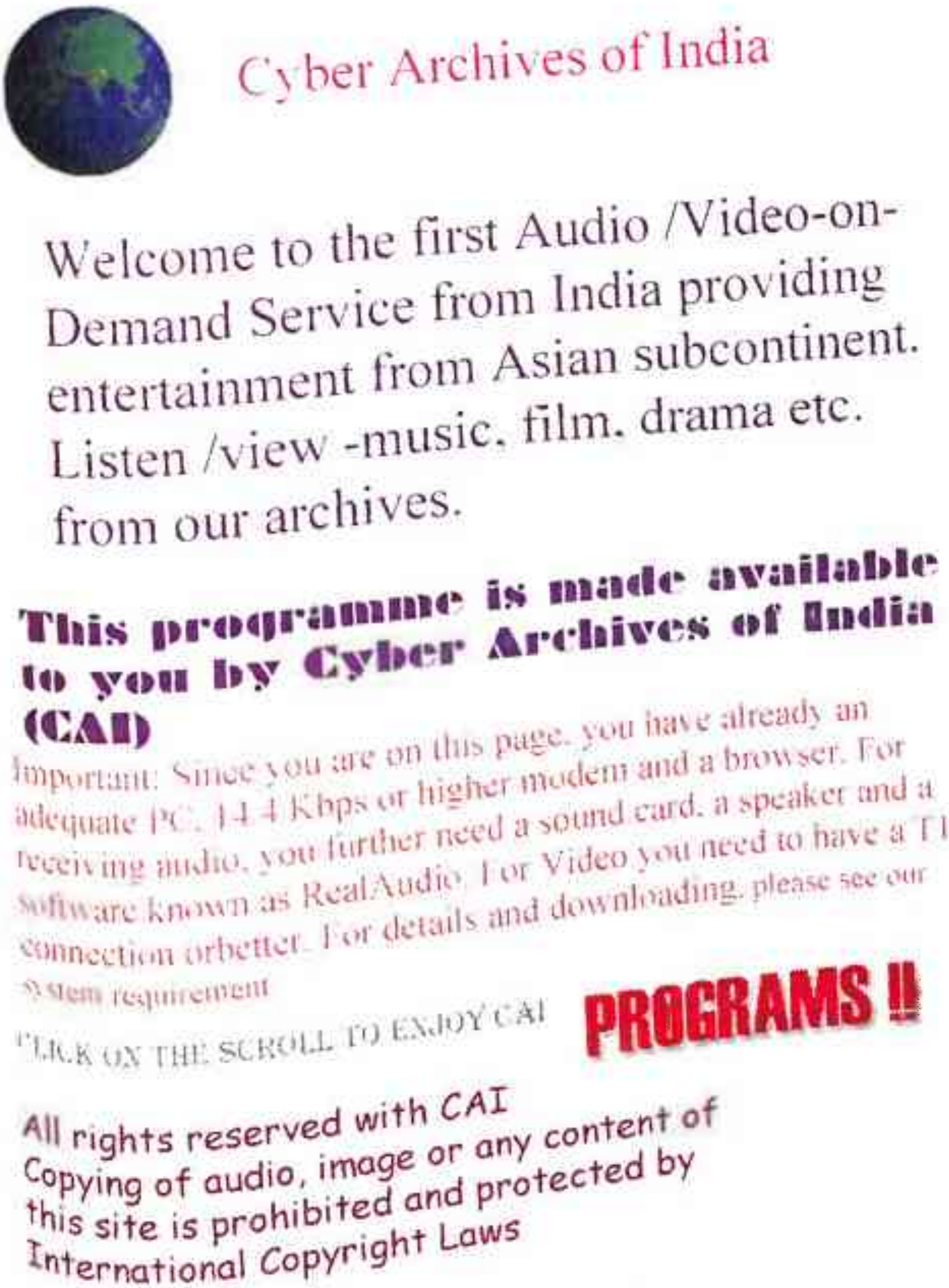


Fig. 4.6 Opening Menu

Cyber Archives of India

This is a new concept of making you available digital multimedia archives.

There are Four modes of delivery:

- Through our broadcast as per predetermined shedules.
- To Producers who have special password on Intranet.
- To the viewers via Internet /ATM/ T-1 connection.
- To the viewers via 14.4 /28.8 kbps modem

Fig. 4.6.1 Selection Menu

Cyber Archives of India

Welcome viewers. We provide you entertainment 24 hours a day. You may enjoy some of the portions without any fee. However for enjoying full access you have to enter into a subscription. Pl. also see the page on rights for viewing /listening/ further distribution.

There are two ways for accessing the material. This is via hypernodes or via category screens/self etc.

Fig. 4.6.1.1. Search Option Menu

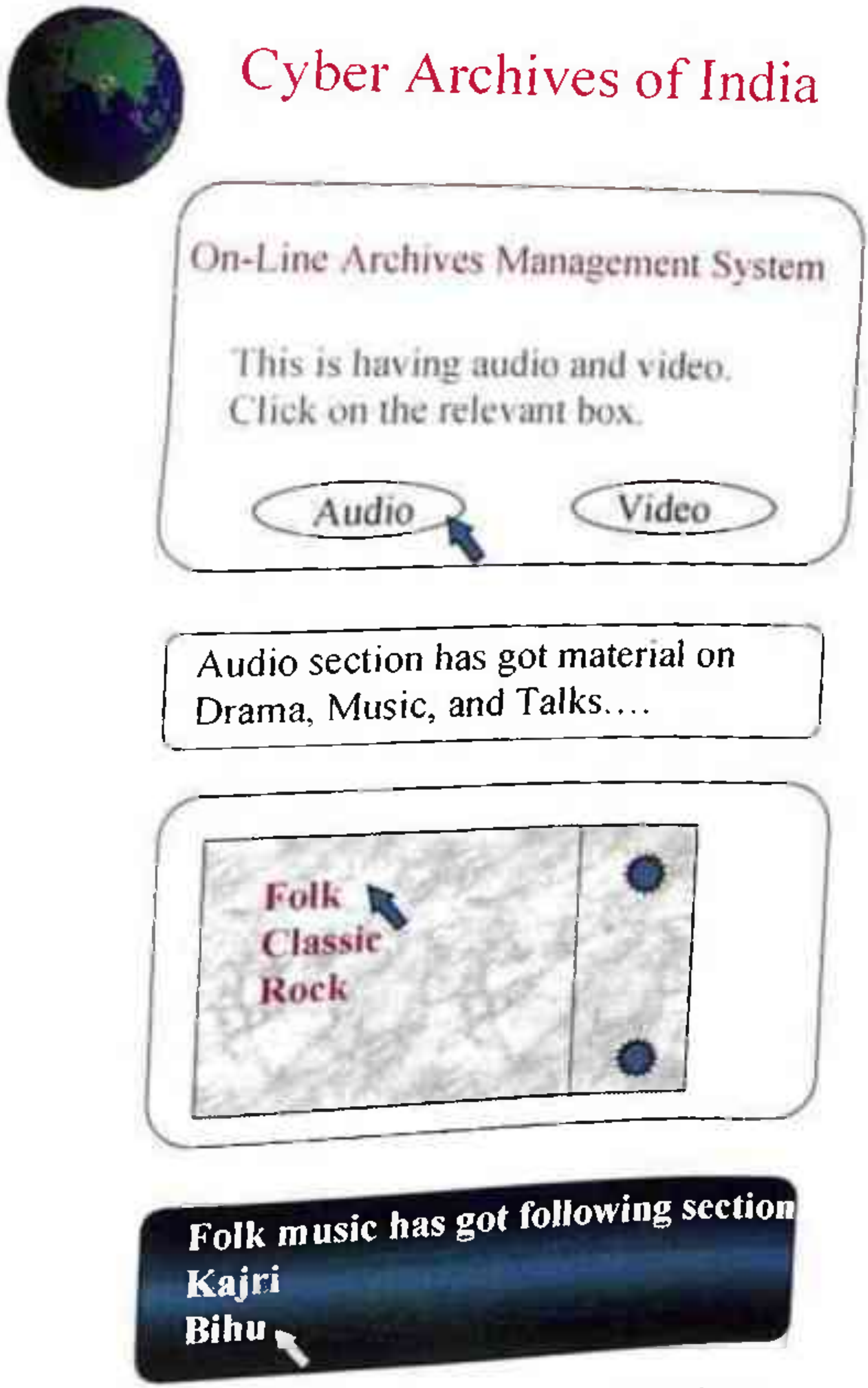


Fig. 4.6.1.1.1 Query by Form Menu

Fig. 4.6.1.1.2.2 Selection by attribute menu

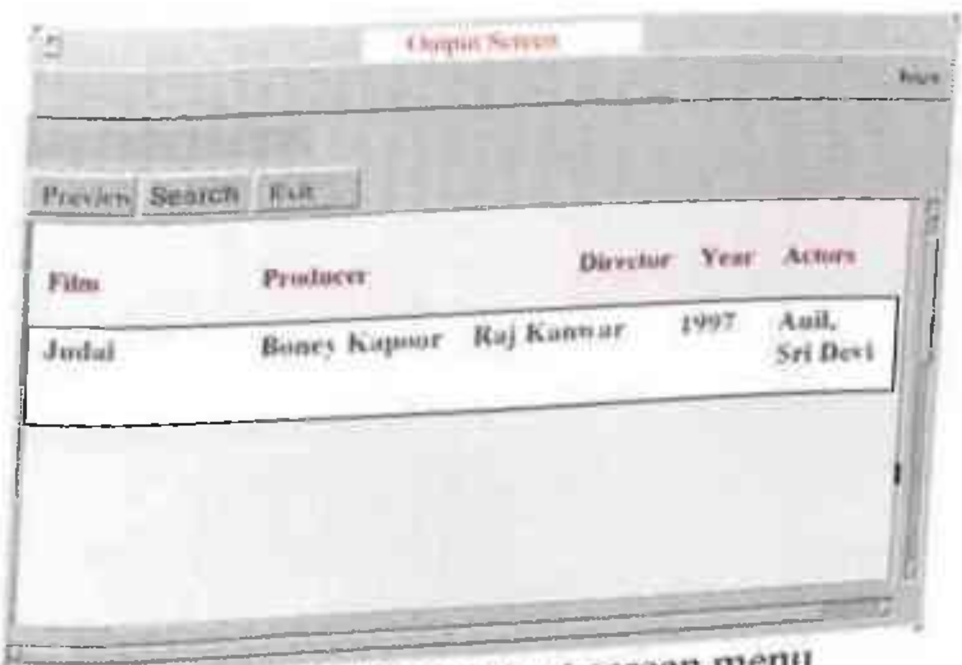


Fig. 4.6.1.1.2.3. Text output screen menu

TRAILER

JUDAAI

PRODUCER: BONEY KAPOOR.
DIRECTOR: RAJ KANWAR.
CAST: ANIL KAPOOR, SRIDEVI, URMILA MATONDKAR, PARESH RAWAL.

Anil Kapoor and Sridevi play a happy couple despite the tiffs between the two over Sridevi's materialistic demands. All's fine till Urmila Matondkar, who plays a spoilt brat arrives on the scene. She falls in love with Anil (who works in her father's factory) and even strikes a deal with Sridevi in a temple to get married to Anil (yes, the second time) in exchange of a crore rupees.

The story takes a twist when Urmila with her affection for children, wins Anil's heart while Sridevi is left counting notes! A remorseful Sridevi tries to win Anil back...

Fig. 4.7 Movie Detail Screen Menu

4.8 Performance Evaluation

Two types of performance evaluations were made as a part of this research. One was the picture degradation in digital domain after successive dubbings. and the other was the subjective listening /viewing of the audio /video-on-demand service via Internet. These are described now.

4.8.1 Picture degradation on successive dubbings

The digital video was re-recorded on a machine several times to create ten generations of the recordings. It was found that the picture degradation in terms of S/N ratio was almost negligible. The data on digital degradation after successive dubbings as compared with the literature data for degradation of analog dubbings is shown in Fig. 4.8.

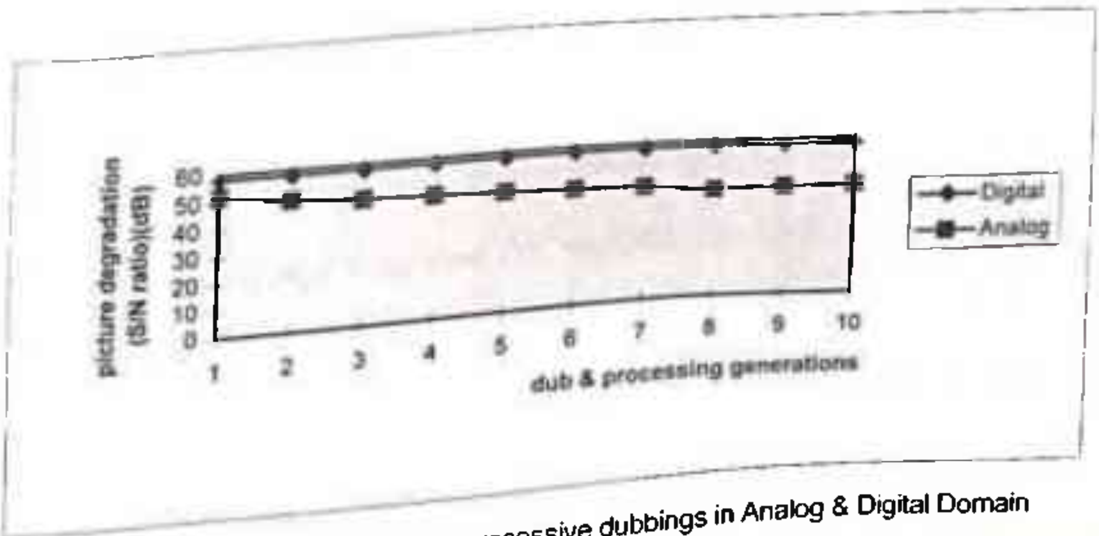


Fig. 4.8 Picture degradation on successive dubbings in Analog & Digital Domain

It was found that in digital domain, the picture degradation was negligible, after ten dubs, as against a -10 dB degradation in analog domain. However, the things are not as good with the compression. A compression of 1:2 gives a picture degradation of about 5 dB. Although degradation afterwards in successive dubbings is nil.

8.2 Subjective Listening Viewing observations

The subjective listening /viewing observation of audio / video received from a number of Web sites was made at Delhi (India). The line connection was at 9600, 14400, an 28800 bps. The audio quality was found to be of AM broadcast but with breaks at 9600 bps. Sometimes the audio was found to be choppy due to packet loss. This packet loss was due to unreliability of transmission media. Using a 14.4 kB/s modem, the audio was of AM broadcast quality and video was pixelated with frames being displayed every 10 or 12 seconds. The performance dramatically improved with a faster CPU (Pentium with 100 MHz clock speed) and faster modem (28.8 kB/s). While the audio was of near FM quality, video were still found to be slow and jerky although image quality was good. Since higher quality lines were not available, few Web sites were also surfed to find the reported quality of audio and video at higher connection speeds. Based on these observations and searches, the quality of the audio/video on different connection speeds is shown in Table 4.2.

The analysis of the data reveals that at present, for available modem speeds, technology is acceptable for audio broadcasting but barely useable for video broadcasting. However, the delivery of video with 64 kB/s or better speeds, is perfectly acceptable. Another contributing factor for both audio and video broadcast, is the type of programme - recorded or live. Because of the high demands of the compression on-the-fly, live audio/video delivery results in more deterioration in quality.

Table-4.2

Connection Speed and Quality

Connection type	Speed (kB/s)	Audio Quality	Video Quality
Dial-up modem[1]	9.6-14.4	8kHz. AM radio	-
"	14.4	AM radio	Pixelated & blocky frames (every 10 or 12 seconds)
"	28.8	16/22kHz.mono, Near FM	Good image quality displayed (every 2 or 3 seconds)
Frame relay/ISDN[2]	56-64	44 kHz Stereo, Near CD	Good low motion video, High motion clips distorted.
ISDN, two B channel[3]	128	Stereo hi-fi	30 fps full motion video at quarter screen resolution.
T1	384+		VHS, MPEG-1 quality

Source: 1. Listening / Viewing Observations at Delhi (India),
2. http://www.firstadio.com/listen.html,
3. http://www.xingtech.com/sw.winclient/info/tsg-win.html

Chapter

5

Broadcast Archives for India : Few Issues

India has a rich cultural heritage and the broadcast archives have about 100,000 holdings of great value. Part of these holdings are exclusive properties of AIR/TV India while for others it has to pay royalty for every use. While deciding the type of solution for India, we have to consider a number of issues relating to their locations, present IS, availability of Internet / Intranet systems, global scenario and the finances required to implement the system. We would consider these aspects in this Chapter.

5.1 Rich Cultural Heritage in India Archives

India is a vast country with unmatched diversity. It has a very rich and ancient cultural heritage. Classical and Folk music has been a part of life of the people. The country's musical heritage are the recordings of memorable, soul stirring recitals by master musicians like - Abdul Karim Khan, Allauddin Khan, Amir Khan, Bade Gulam Ali Khan, Begam Akhtar, D.V. Pulskar, Faiyaz Khan, Hafeez Ali Khan, Hirabai Barodkar, Om Nath Thakur, Panna Lal Ghosh, Rasoolan Bai, Sidheshwari Devi, etc. All India Radio and TV, India have the unique privilege of holding recordings of these musics and also eminent Indian personalities which depict the various phases of the transformation of this country. Apart from this the archives have drama skits, talks, folk music, films, effects etc.

5.2 Present IS for Archives

Prior to 1988, the holdings were divided into a number of categories on the basis of content of the holding. Dewey's decimal system and Library of Congress cataloging system were used. The details were put on the cardex system. One had to manually scan the cardex system to locate a holding. Thus it was very time consuming to find the holding satisfying one or more classification conditions.

In 1988, a computerized Tape Archives Management System (TAMS) was developed by me to provide instantaneous retrieval of information satisfying the lowest classification levels. The Information System consists of a database using a relational DBMS (Data Base Management System). A software structure of Tape Archives Management System (TAMS) used is shown in Fig. 5.1.

Fig. 5.1 Software structure for TAMS

A 'data dictionary" is a catalogue of all the data types in the data base giving their names, definitions an characteristics etc. In case of broadcast archives the data dictionary contains the details of the data entity, data definition etc. such as type of recording, holding details, name of the signer etc. There are conventional menus for data entry. Report generation is done through a report writer program and 4GL query languages allow unstructured searches. It will be seen from Fig. 5.1 that in case of TAMS, the "Informix" database directly interacts with the operating system "Unix". A report writer "Ace" coupled with the conventional "Fortran" or "C" is used for report writing. A 4G Query language "Informer" allows unstructured query. The details of TAMS is described in the following sections.

5.2.1 Design Details of TAMS

5.2.1.1 Categorization of Holdings

The holdings span into various major categories covering a large number of disciplines. Each of these categories cover all tapes and discs containing archival details for a particular area (Table 5.1). For example, all the holdings related with Mahatma Gandhi's recordings are categorized as "MG". On the basis of usage of various recordings, all the holdings are further classified into 21 major areas. A separate database file is maintained for each of these areas. Table 5.2 defines the various holdings and the corresponding file names in the database.

Table 5.1

Categories of Archives holdings

S.NO.	Category	Description of holdings
1.	MG	MAHATMA GANDHI
2.	PM	PRIME MINISTERS.
3.	P	PRESIDENTS.
4.	EP	EMINENT PERSONS.
5.	SN	SANSKRIT
6.	NPT	NATIONAL PROG OF TALKS
7.	SPT	SPECIAL PROG OF TALKS
8.	NPP	NATIONAL PROG OF PLAYS.
9	SPP	NATIONAL PROG OF PLAYS.
10.	NPF	NATIONAL PROG OF FEATURES.
11	SPF	SPECIAL PROG OF FEATURES
12.	NPO	NATIONAL PROG OF OPERA
13.	SPO	SPECIAL PROG OF OPERA
14.	SE	SOUND EFFECTS
15.	NPM	NATIONAL PROG OF MUSIC
16.	SPM	SPECIAL PROG OF MUSIC
17.	MI	INSTRUMENTAL MUSIC
18.	MVL	VOCIAL LIGHT MUSIC
19.	MVF	VOCAL FOLK MUSIC
20.	MO	ORCHESTRA MUSIC
21.	PS	PATRIOTIC SONGS
22	SS	STAGE SONGS

Table 5.2

Files in the TAMS

S. No.	File Name	Holdings Covered	Category
1.	CARNATIC	CARNATIC MUSIC	NPM,SPM,MI
2.	EPH	EMINENT PERSON SPEAKING	EP, P, PM, MG
3.	EPO	EMINENT PERSON SPOKEN BY	EP, P PM, MG.
4.	HINDUSTANI	HINDUSTANI MUSIC	NPM,SPM,MI
5.	MF	FOLK MUSIC	NPM,SPM,MI
6.	ML	LIGHT MUSIC	NPM/SPM/MVL/MI
7.	MO	ORCHESTRA MUSIC	MO
8.	FEATURES	FEATURES	NPF,SPF,MI
9.	OPERA	OPERA	NPO,SPO,MI
10.	PLAYS	PLAYS	NPP,SPP,MI
11.	TALKS	TALKS	NPT,SPT,MI
12.	PS	PATRIOTIC SONGS	PS
13.	SE	SOUND EFFECTS	SE
14.	SN	SANSKRIT.	SN
15.	SS	STAGE SONGS	SS

5.2.1.2 Scheme of Codification

For efficient computerization, a number of items are stored in codified form.

5.2.1.3 Data Capture and Entry

TAMS collects various information required by it using a number of especially designed input forms. Each of these forms cater to the recording details of a particular type of file. Following two types of details are being maintained for each type of recording:

- Identification details of a holding.
- Specific details about the holding.

Identification details are common for all types of holdings. These include, details such as, holding no. unit no. recording speed / format, location in archives, language, occasion, station, duration, date, state and place of recording, the copyright and date of first broadcast, etc.

Specific details vary from holding to holding. Holdings on music, songs, VVIPS spoken on, VVIPs speaking themselves, Sanskrit programme, effects, opera, talks, plays and feature films have different specific details. For example, the specific details required for collecting data on holdings containing recordings on Carnatic music are- type of music, raga, codes for artists, the names of accompanists and the instruments played by them, the composer of the music, first line of music, and the code of main instrument if it is a instrumental music.

For each of the database file, a separate screen data entry forms is used. The system generates executable modules for screen data entry

5.2.1.4 System Outputs and Report Generation

The Report Generation System of TAMS generates about 90 types of statements. These statements can broadly be categorized into the following categories:

5.2.1.4.1 Header Reports

These reports print a summary statement for the total number of tapes in a particular file. It prints the total number of tapes and the total time of recording for each type of tape being maintained in the system as on a specific date

5.2.1.4.2 Q. Sheets

These Reports print a catalogue type of statement showing every detail about a type of recording on the tapes maintained in different files

5.2.1.4.3 *Special Reports*

These are special purpose reports which cover the most common queries to be answered about the tape recordings whose details are being maintained in different TAMS files.

5.2.1.4.4 Unstructured Query

In addition to above, a number of specific query reports may be generated from the system about an specific information, using the On-line Query Facility.

5.2.2 Problems of TAMS

The main problems of the TAMS is it's extensive use of codes and use of SQL query language. For making unstructured query, a producer has to learn the SQL and use the codes to structure his query. The producers are reluctant to use it. Moreover, this is based on a central computer system with slave terminals and is not suited for distributed data processing. Besides all the disadvantages of the analog system, this is not designed to serve the listeners and viewers.

5.3 Archives and other network avaiability in India

All India Radio is one of the earliest broadcasting organizations in the world, having started broadcasting in 1936. TV India, which was a part of All India Radio, got separated in 1977. These departments act as prime carriers for the message of development along with news, views, information, education, health, hygiene, and message of national and international understanding. All India Radio has 192 radio stations with 144 MW, 52 SW, 101 FM transmitters and TV India has 41 Programme Production Centres with 92 HPT, 638 LPT, 173 VLPT, 20 transposers as on 20.08.1997. All the production units have got a local archive attached to it. The Central archives for both these organizations are in Delhi at separate locations. Most of the recordings are in analog format. The present IS is a mix of manual and Computer based retrieval system. Both these organizations want to develop an Information System for their archives for which they are seeking plan allocations in the next plan. The partial computerized IS was developed by me.

In India, Videsh Sanchar Nigam Limited (VSNL) has provided INTERNET facility at six locations viz. Delhi, Bombay, Bangalore, Pune, Lucknow and Madras. These are being extended to 12 more locations. There are 5000 Internet Users in India as on date. VSNL expects that the users will grow to one hundred thousand by next year. Department Of Telecommunication (DOT) has provided I-NET facility at centres which are expected to be expanded to 86 major locations by the year end. I-NET is a public packet-switched data network and supports CCITT standard protocols/interfaces: X.3, X.28, X.29, X.25 and X.75. It is possible to access Internet using INET. Internet can also be accessed through a modem using dial-up link using TCP/IP protocol or through dedicated leased line. DOT is also planning to provide T-1 connection in the near future.

Under the National Telecom Mission, Department of Telecommunication and Department of Electronics have established data communication networks in the country. Besides I-NET, National Informatics Centre has established NICNET for Govt. information and CMC has established INDONET for commercial use. NICNET connects 450 district headquarters and 32 state and union territory capitals with the central hub in Delhi. It uses 500 VSATs (Very Small Aperture Terminals) connected via INSAT 1D. The other networks are INFLIBNET (connecting libraries of CSIR, ICMR, ICAR, DRDO etc.), ERNET (Connecting institutions) etc.[251].

All India Radio have started experimenting the DAB service and planning to start digital service in the next plan, commencing from 1997. TV India is already planning to start DTH service by the year end by hiring transponder on MEASAT (Malayasian Satellite). TV India has also hired a transponder on PanAmSat-4. A [illegible] for DTH TV on the orbital slot of 95^0 east, and with a high power Ku band satellite to INTELSAT. This satellite which will foot print over India is being launched by become operational by 1998, has two fixed high-power beams with a signal strength of 55 dBW over India. This is the e.i.r.p of the footprint over India. INTELSAT has already six satellites serving India. Indian Broadcasters on INTELSAT 703 are Asianet, BiTV, NEPC, and Sun TV.

Internet Information Server and the solution for Intranet is already available in this country. All India Radio has also created it's Web page, although the service at present is text based. A download of Web page is given in Fig. 5.2. A private enterprise has started an audio-on-demand service from Delhi (Fig. 5.3). A number of web sites have been established by private enterprises namely, Times of India, Indian Express, Madhuri, ABCL, Shahnaz Hussain etc., albeit all of these are on web servers located in the USA.

5.4 Recommended System for India

From the preceding sections, we see that the present IS for archives, though DBMS based, is not suited for the future broadcast environment. We also find that the country has matured Internet Gateway, Data Circuit and has recorded it's presence on the Information Superhighway. AIR and TV, India have planned to start DAB, DTH and Internet Broadcasting in the next plan. Under these circumstances, we recommend for India the same IS as we have proposed in Chapter 4 of the thesis. However, the present network may not allow the interlinking of all the AIR and TV centres immediately. As such, in the first phase the IS as recommended, may be developed and used at all the centres and the

A I R Online Information Service

Welcome to the Home Page of All India Radio (AIR). This experimental service has been started on May 02. 1996 with news coverage in TEXT mode.

All India Radio is India's only Radio network. For the last nearly 70 years, All India Radio has been taking a major role in the development process of the nation by disseminating 'information', 'education' and 'entertainment' to the people of India.

Last Updated at 1300 Hrs. India Time on December 15, 1996

News Update
Yesterday's News
AIR's External Services -- Frequency Schedule

All contents Copyright © by All India Radio. All information received from this computer system is protected under international copyright law . This information is provided under the terms & conditions.

Fig. 5.2 Web Page of AIR

RADIOASIANET

NEWS

English

Hindi

The Most comprehensive News Capsule in both Hindi & English. Our RadioAsiaNet bureau goes in the depth to get you the facts, be it on Politics, Economics, Entertainment or Sports

The News is updated daily.

Main :[Home] [RadioAsiaNet Info] [Advertising] [FeedBack] [System Requirements]
Programs : [News] [CountDown Curry] [Down Memory Lane] [RadioAsianet Plus][FastForward]

Fig. 5.3 Web page of a private audio-on-demand service stations where INET, Internet, or NICNET hubs are available, may be interlinked. As and when the linking is possible all the places may be linked.

5.5 Financial Considerations

The 9th Plan allocation of these two organizations are likely to be of the order of Rs. 4000 crores. AIR has already got sanctioned a scheme for it's permannent archives at Todapur, New Delhi with an allocation of Rs. 15 crores. AS such a beginning can be made in this direction immediately.

Chapter

6

Future Trends and Conclusion

Audio /video database are becoming popular with the advent of hardware technology, broadband network (ISDN and ATM) and compression standards (JPEG, H.261 and MPEG). Typical audio/video database applications are in the areas of multimedia information systems, entertainment (e.g. interactive television), digital libraries, education systems, etc.

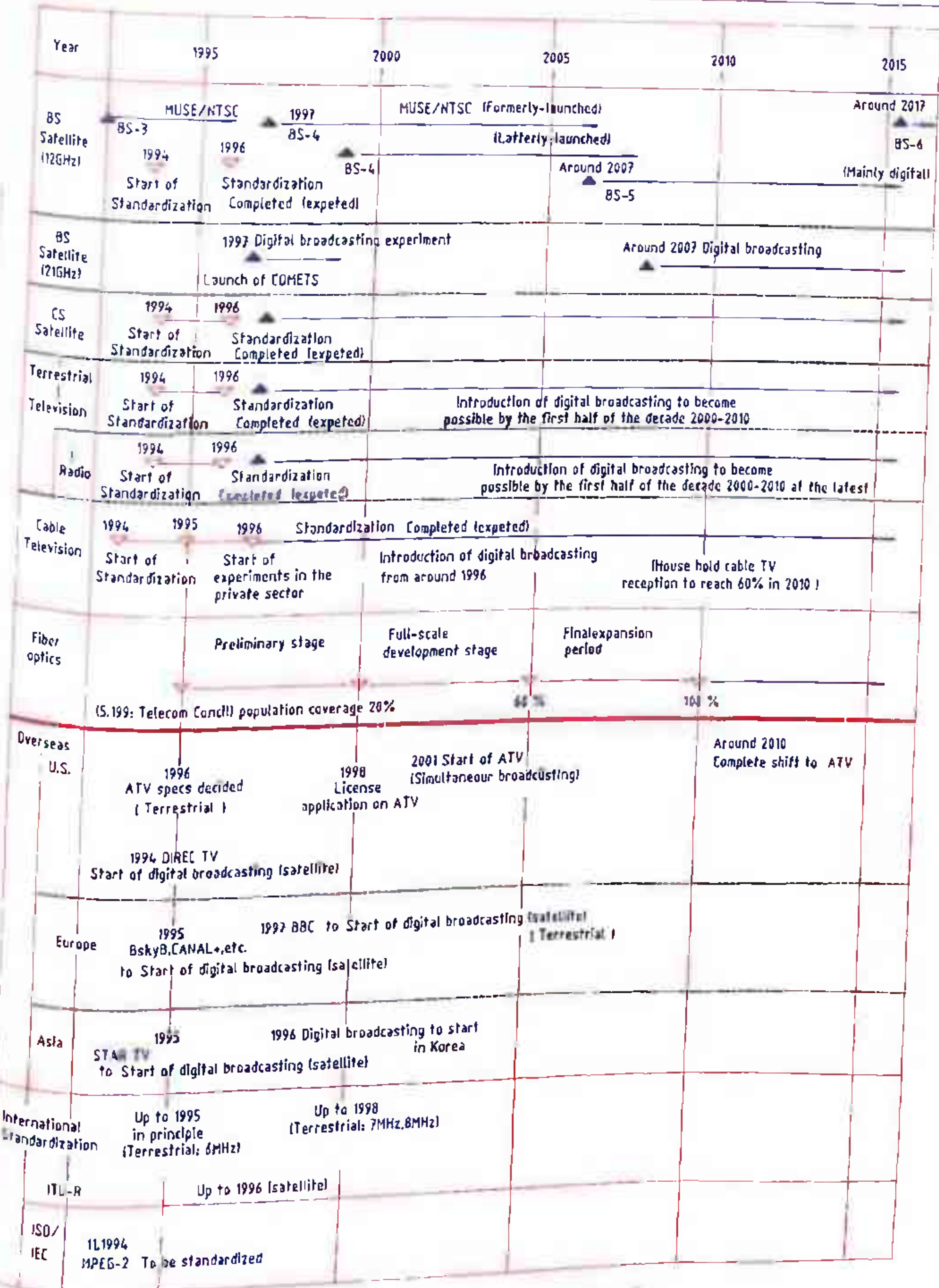
Indexing is an important tool to facilitate the access and several techniques have been recently proposed. However, all of these techniques operate on the visual data in the original (pixel) domain. Since most of the future visual data is expected to be stored in the compressed form, it is important to investigate indexing approaches in the compressed domain. An important step in video indexing is scene change detection.

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 may be interested in accessing a variety of programmes either using on-line 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 the clips. An automated system with a multimedia archival support may be a solution. A hyperlink based retrieval system has specific advantages. The present thesis 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 analyzing the user behavior. This evolutionary development and the diffusion process may take some years. But the potential benefits for the broadcast organizations are high. To quote Bill Gates, "Whatever problems direct access to unlimited information may cause, the benefits it will bring, will more than compensate[252]."

6.1 Future Scenario

Rabiner [253] states that the vision of multimedia communication in the year 2001 contains simple-to-use ways for people to manipulate their complex and rich communication environment comprising of speech, music, still and motion video. Broadcasters have already planned implementation schedule for digital multimedia delivery by 2010 (Fig. 6.1). Some of the technology that is in offing for video/audio delivery and which shall play a key role for interactive broadcasting and digital archives are given now.

Future Prospects for the Introduction of Digital Broadcasting



1. Digital broadcasting has already been introduced for BS and CS audio broadcasting
Concerning the possible date for introduction of digital BS broadcasting (12 GHz)

Fig. 6-1 Planned Digital Broadcast Services

6.1.1 Web Voice Browser

Web-On-Call Voice Browser uses text-to-speech technology to read back information on a Web Server to a user calling into the Web site. This has special application in broadcasting since the news of specific importance can be received on an ordinary phone or a cell phone [254].

6.1.2 Multicast IP

IETF (Internet Engineering Task Force) is finalizing standards for multicast IP traffic over ATM [255]. This will allow multicasting of multimedia data on the Internet in a broadcast like mode where a number of viewer are addressed simultaneously through routing of the same packets.

6.1.3 Video Parsing and Scene Detection by Retrieval of key frames

Parsing consists of two tasks: temporal segmentation of a video program into elemental units, and content extraction from those units, based on both video and audio semantic primitives [256]. Many effective algorithms are now available for temporal segmentation [257, 258]. However, fully automated content extraction is a much more difficult task, requiring both signal analysis and knowledge representation techniques. Research in this direction should ultimately lead to an intelligent video parsing system [259, 260, 261].

Institute of Systems Science, National University of Singapore is working on such an algorithm. They have a three stage approach: The first is temporal segmentation. At the second level each segment is abstracted into key-frames, based on a simple analysis of content variation. Finally, visual features, such as color and texture, are used to represent the content of key-frames. In addition, variations among key-frames from the same shot are calculated and integrated with information about camera operation and object motion to provide event-based cues. Indexing is then supported by a clustering process which classifies key-frames into different visual categories. After the key frames have been retrieved and indexed, these can be used to start playback of the video from that frame till the next key frame is encountered.

6.2 Viability of the proposition

A survey done by NHK has suggested that future interactive broadcasting will be accepted by the audiences [262]. A model was also developed to determine the business potential of interactive video. It was concluded that the profit can be gained for a programme if 0.1% of the viewers use the interactive mode to access the multimedia databases. This profitability can be further improved by cutting down the cost of production with the use of multimedia databases and on-line production techniques. The other benefit is increase in viewer's satisfaction [263].

6.3 Conclusion

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 and other low bit rate coding like Fractal /

Wavelet, 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) 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, 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 archives hold valuable collection of music, film, talks, sound effects, video clips, still pictures etc. The archival material consists of video or audio disks/tapes generally stored in analog format. 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 and user's need for interactivity. IBM has taken up a project of this kind by developing an information system for Vatican library.

In this thesis we have discussed the multiple aspects of digital broadcast archives that may cater to the needs of automated, interactive, multi-channel delivery systems. We have developed a system architecture and IS model for broadcast archives using Object Oriented Database (OODB), CORBA (COmmon Request Broker Architecture) and JAWA. The proposed On-Line Broadcast Archives Management System (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 and storing it on multiple servers. 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.

Digitized hypermedia data is stored on the media servers. Secondary information resources such as hyper-linked HTML documents, databases of static images, meta data and ftp sites of reference-archives are also stored on the server. Server push allows delivery of multimedia content without requiring the customer to request or "pull" the information. With this mechanism the server sends down a chunk of data. The browser displays them leaving the connection open to receive more data for a fixed time or until the client interrupts the connection. A Java applet is used to make it's own network connection using sockets. The databases are accessed from an applet directly, without any interventions by the HTTP server. An applet, once connected to a database, keeps the connection open as long as the applet is alive and the user is in session. The real potential of utilizing Java for interactive queries and complex database transactions lies in the mobility and connectivity of Java applets. A Java applet running on a Java-enabled browser functions like a self-contained Web client. The user is able to get the information either by video-query screens or through hypermedia nodes. Access control is used to protect the unauthorized use of the material.

The advantages of the IS for broadcast archives, developed by us are enumerated below.

- The archive architecture includes all the aspects including creation and capture, storage, rights management, search and access, and distribution. This is a departure from the traditional system where distribution is not included in the archive architecture.
- The archives are in digital format and reside on video server, CD, OD, etc.
- Most of the holdings are on-line which can be accessed by a viewer.
- For those holdings which are not on-line, an excerpt is available for preview.
- The indices, picture segments and clippings are derived through key-frame extraction algorithm, where possible.
- The search is through hypermedia nodes, keywords or video browsers.
- Access control allows protection of intellectual property rights.
- The digital delivery is provided through Information Superhighway which allows access at any time by any person from any geographical location.
- A JAVA applet allows capture of viewer's preferences. This allows providing a specially designed programme package to individual viewer using server push technology. This really means possibility of a new channel to every individual.

6.4 Future work

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, redesigning business processes, enabling broadcast companies to capture global economies of scale and provide services globally. We have presented in this thesis a model for Information System integrating a number of emerging complex technologies. The idea behind the IS is that the system should be able to provide access to any archive data, to anybody, from anywhere at any time through any existing computer network like the Internet or other private networks which may make a lane in the future Information Superhighway. The electronic distribution of broadcast archive objects requires large bandwidth not usually available in many existing networks. While most business data can easily be transmitted over current phone lines, new technologies are required for large multimedia objects used for broadcasting, e.g., fiber optics, Asynchronous Transfer Mode (ATM) switches, network management software, etc. The flexibility to locate the media servers close to the users can also provide better performance. Though the normal terrestrial mode of one-way delivery may continue during the next two-three decades, this will greatly be supplemented by interactive two-way transmission systems of Information Superhighway. The proposed IS is to cater to this need. ISO has already started work on two standards MHEG-5 and MHEG-6, the future standards for coding of multimedia and hypermedia objects. This will further provide new directions in delivering multimedia data on the information superhighway.

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