17BEBME6E02 TELEHEALTH TECHNOLOGY 3 0 0 3 100

OBJECTIVES:

The student should be made to:

- Learn the key principles for telemedicine and health.
- Understand telemedical technology.
- Know telemedical standards, mobile telemedicine and it applications.

OUTCOMES:

At the end of the course, the student should be able to:

- Apply multimedia technologies in telemedicine.
- Explain Protocols behind encryption techniques for secure transmission of data.
- Apply telehealth in healthcare.

UNIT I TELEMEDICINE AND HEALTH 9

History and Evolution of telemedicine, Functional diagram of telemedicine system, Telemedicine, Telehealth, Tele care, Organs of telemedicine, Global and Indian scenario, Ethical and legal aspects of Telemedicine - Confidentiality, Social and legal issues, Safety and regulatory issues, Advances in Telemedicine.

UNIT II TELEMEDICAL TECHNOLOGY 9

Principles of Multimedia - Text, Audio, Video, data, Data communications and networks, PSTN,POTS, ANT, ISDN, Internet, Air/ wireless communications: GSM satellite, and Micro wave, Modulation techniques, Types of Antenna, Integration and operational issues, Communication infrastructure for telemedicine – LAN and WAN technology. Satellite communication. Mobile hand held devices and mobile communication. Internet technology and telemedicine using world wide web (www). Video and audio conferencing. Clinical data – local and centralized.

UNIT III TELEMEDICAL STANDARDS 9

Data Security and Standards: Encryption, Cryptography, Mechanisms of encryption, phases of Encryption. Protocols: TCP/IP, ISO-OSI, Standards to followed DICOM, HL7, H. 320 series (Video phone based ISBN) T. 120, H.324 (Video phone based PSTN), Video Conferencing, Real-time Telemedicine integrating doctors / Hospitals, Clinical laboratory data, Radiological data, and other clinically significant biomedical data, Administration of centralized medical data, security and confidentially of medical records and access control, Cyber laws related to telemedicine.

UNIT IV MOBILE TELEMEDICINE 9

Tele radiology: Definition, Basic parts of teleradiology system: Image Acquisition system Display system, Tele pathology, multimedia databases, color images of sufficient resolution, Dynamic range, spatial resolution, compression methods, Interactive control of color, Medical information storage and management for telemedicine- patient information medical history, test reports, medical images diagnosis and treatment. Hospital information system - Doctors, paramedics, facilities available. Pharmaceutical information system.

UNIT V TELEMEDICAL APPLICATIONS 9

Telemedicine access to health care services – health education and self care. · Introduction to robotics surgery, Telesurgery, Telecardiology, Teleoncology, Telemedicine in neurosciences, Electronic Documentation, e-health services security and interoperability., Telemedicine access to health care services – health education and self care, Business aspects - Project planning and costing, Usage of telemedicine.

Total : 45

TEXT BOOK

S.NO.	Author(s) Name	Title of the book	Publisher	Year of publication
1	.Norris, A.C	Essentials of Telemedicine and Telecare	Wiley	2002

REFERENCES:

S.NO.	Author(s) Name	Title of the book	Publisher	Year of publication
1	Wootton, R., Craig, J., Patterson, V	Introduction to Telemedicine. Royal Society of Medicine	Taylor & Francis	2006
2	O'Carroll, P.W., Yasnoff, W.A., Ward, E., Ripp, L.H.,	Public Health Informatics and Information Systems	Springer	2003
3	Ferrer-Roca, O., Sosa - Iudicissa, M.	Handbook of Telemedicine. Technology and Informatics	IOS Press (Studies in Health) Volume 54	2002
4	Simpson, W.	Video over IP, A practical guide to technology and applications	Focal Press Elsevier	2006
5	Bemmel, J.H. van, Musen, M.A.	Handbook of Medical Informatics	Springer	1997
6	Mohan Bansal	Medical Informatics	Tata McGraw-Hill	2004

KARPAGAM ACADEMY OF HIGHER EDUCATION
(Deemed to be University Established Under Section 3 of UGC Act 1956)
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FACULTY OF ENGINEERING
DEPARTMENT OF BIOMEDICAL ENGINEERING

LECTURE PLAN

NAME OF THE STAFF : Ms. S. SREE SANJANAA BOSE

DESIGNATION : ASSISTANT PROFESSOR

CLASS : B.E-III YEAR BME

SUBJECT : Telehealth Technology

SUBJECT CODE : 17BEBME6E02

S.No	TOPICS TO BE COVERED	TIME DURATION	SUPPORTING MATERIALS	TEACHING AIDS
UNIT-I TELEMEDICINE AND HEALTH				
1.	History and Evolution of telemedicine	01	T1 - 1-3	PPT
2.	Functional diagram of telemedicine system	01	T1 - 7-24	PPT
3.	Telemedicine, Telehealth	01	T1 - 25-30	PPT
4.	Tele care, Organs of telemedicine	01	T1 - 36-38	PPT
5.	Global and Indian scenario, Ethical	01	T1 - 68	PPT
6.	legal aspects of Telemedicine	01	T1 - 69	PPT
7.	Confidentiality, Social and legal issues	01	T1 - 70	PPT
8.	Safety and regulatory issues	01	T1 - 568	PPT
9.	Advances in Telemedicine	01	T1 - 569 - 570	PPT
Introduction		**01**		
Total Lecture Hours		**08**		
Total Hours		**09**		

UNIT-II TELEMEDICAL TECHNOLOGY				
10	Principles of Multimedia - Text, Audio, Video, data	01	T1 – 148 - 149	PPT

11	Data communications and networks, PSTN,POTS, ANT, ISDN	01	T2 – 150 – 151	PPT
12	Internet, Air/ wireless communications: GSM satellite, and Micro wave, Modulation techniques,	01	T1 – 152 - 154	PPT
13	Types of Antenna, Integration and operational issues, Communication infrastructure for telemedicine – LAN and WAN technology	01	T2 – 175 - 203	PPT
14	Satellite communication. Mobile hand held devices and mobile communication	01	T1 – 156 - 157	PPT
15	Internet technology and telemedicine using world wide web (www).	01	T1 – 568 - 569	PPT
16	Video and audio conferencing	01	T2 - 161	PPT
17	Clinical data	01	T3 – 34 - 92	PPT
18	local and centralized.	01	T2 – 137 - 165	PPT
Total Lecture Hours		**09**		
Total Hours		**09**		

UNIT-III TELEMEDICAL STANDARDS				
19	Data Security and Standards: Encryption, Cryptography, Mechanisms of encryption, phases of Encryption. Protocols: TCP/IP, ISO-OSI	01	T1 – 120 – 127	PPT
20	Standards to followed DICOM, HL7, H. 320 series (Video phone based ISBN) T. 120, H.324 (Video phone based PSTN),	01	T1 – 128 – 139	PPT
21	Video Conferencing, Real-time Telemedicine integrating doctors / Hospitals	01	T1 – 106 - 107	PPT
22	Clinical laboratory data, Radiological data, and other clinically significant biomedical data	01	T1 - 157	PPT
23	Administration of centralized medical data	01	T1 - 152 - 157	PPT
24	security	01	T1 - 332 - 336	PPT
25	confidentially of medical records and access control	01	T1 - 289 - 290	PPT

26	Cyber laws related to telemedicine.	01	T1 – 390 - 410	PPT
Total Lecture Hours		**09**		
Total Hours		**09**		

UNIT-IV MOBILE TELEMEDICINE				
27	Tele radiology: Definition, Basic parts of teleradiology system: Image Acquisition system Display system	01	T1 – 351 - 353	PPT
28	Tele pathology, multimedia databases, color images of sufficient resolution	01	T1 – 290 - 297	PPT
29	Dynamic range, spatial resolution, compression methods	01	T1 – 351 - 352	PPT
30	Interactive control of color, Medical information storage and management for telemedicine	01	T1 – 887	PPT
31	patient information medical history, test reports,	01	T1 – 362 - 381	PPT
32	medical images diagnosis and treatment	01	T1 - 368 - 373	PPT
33	Hospital information system - Doctors, paramedics	01	T1 - 446 - 451	PPT
34	facilities available.	01	T1 – 461-468	PPT
35	Pharmaceutical information system	01	T2 - 542	PPT
Total Lecture Hours		**09**		
Total Hours		**09**		
UNIT-V TELEMEDICAL APPLICATIONS				
36	Telemedicine access to health care services – health education and self care	01	T1 – 553	PPT
37	Introduction to robotics surgery, Telesurgery, Telecardiology, Teleoncology	01	T1 - 542	PPT
38	Telemedicine in neurosciences	01	T1 - 548	PPT
39	Electronic Documentation, e-health services security and interoperability	01	T1 - 479	PPT
40	Telemedicine access to health care services – health education and self care	01	T2 - 477 - 504	PPT
41	Business aspects	01	T1 – 507 - 603	PPT
42	Project planning	01	T1 – 577 - 603	PPT

43	Project costing	01	T1 – 607 - 630	PPT
44	Usage of telemedicine	01	T1 – 777 - 783	PPT
45	Usage of telemedicine.	01	T1 – 787 - 795	PPT
Total Lecture Hours		**09**		
Total Hours		**09**		

Total No of Hours for Introduction: 01 Hrs

Total No of Lecture Hours Planned: 44 Hrs

Total No of Hours Planned : 45 Hours

TEXT BOOK

S.NO.	Author(s) Name	Title of the book	Publisher	Year of publication
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REFERENCES:

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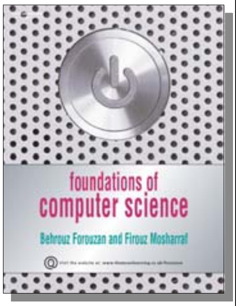
5	Bemmel, J.H. van, Musen, M.A.	Handbook of Medical Informatics	Springer	1997
6	Mohan Bansal	Medical Informatics	Tata McGraw-Hill	2004



15
Data Compression

Objectives

After studying this chapter, the student should be able to:

- ❑ Distinguish between **lossless and lossy compression**.
- ❑ Describe **run-length encoding** and how it achieves compression.
- ❑ Describe **Huffman coding** and how it achieves compression.
- ❑ Describe **Lempel Ziv encoding** and the role of the dictionary in encoding and decoding.
- ❑ Describe the main idea behind the **JPEG standard** for compressing still images.
- ❑ Describe the main idea behind the **MPEG standard** for compressing video and its relation to JPEG.
- ❑ Describe the main idea behind the **MP3 standard** for compressing audio.

Data compression implies sending or storing a smaller number of bits. Although many methods are used for this purpose, in general these methods can be divided into two broad categories: **lossless** and **lossy** methods.

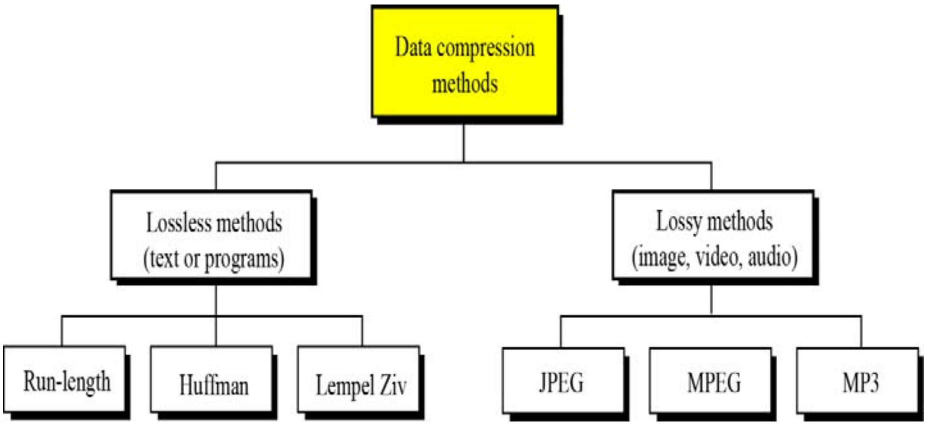


Figure 15.1 **Data compression methods**

15-1 LOSSLESS COMPRESSION

In **lossless** data compression, the integrity of the data is preserved. The original data and the data after compression and decompression are exactly the same because, in these methods, the compression and decompression algorithms are exact inverses of each other: no part of the data is lost in the process. **Redundant data is removed in compression** and **added during decompression**. Lossless compression methods are normally used when we cannot afford to lose any data.

Run-length encoding

Run-length encoding is probably the simplest method of compression. It can be used to compress data made of any combination of symbols. It does not need to know the frequency of occurrence of symbols and can be very efficient if data is represented as 0s and 1s.

The general idea behind this method **is to replace consecutive repeating occurrences of a symbol by one occurrence of the symbol followed by the number of occurrences.**

The method can be even **more efficient if the data uses only two symbols (for example 0 and 1)** in its bit pattern and one symbol is more frequent than the other.

15.5

Example1 of Run-length encoding

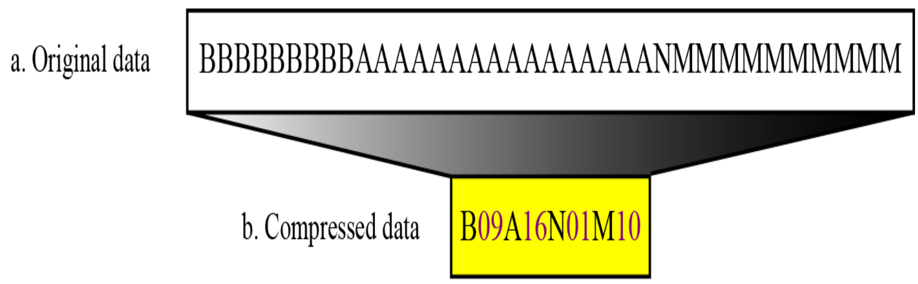
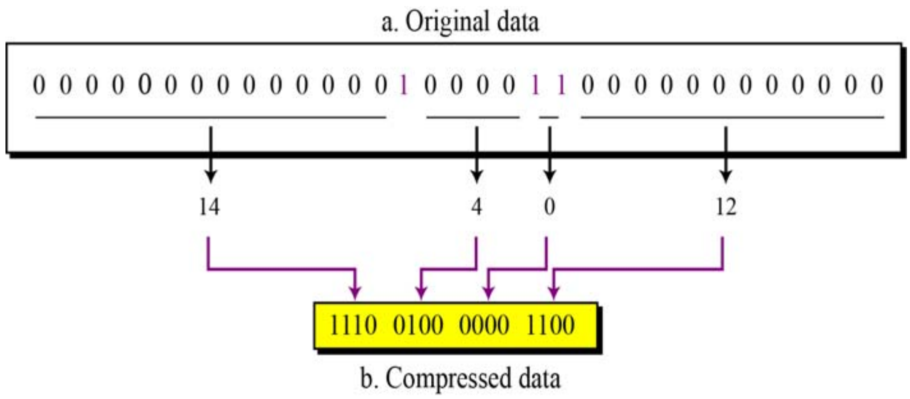


Figure 15.2 **Run-length encoding example**

15.6

Example2 of Run-length encoding



There are **number of 0s** before the **first 1**.

Figure 15.3 **Run-length encoding for two symbols**

15.7

Huffman coding

Huffman coding assigns shorter codes to symbols that occur more frequently and longer codes to those that occur less frequently. For example, imagine we have a text file that uses only five characters (A, B, C, D, E). Before we can assign bit patterns to each character, we assign each character a weight based on its frequency of use. In this example, assume that the frequency of the characters is as shown in Table 15.1.

Table 15.1 Frequency of characters

Character	A	B	C	D	E
Frequency	17	12	12	27	32

#bits = 3bits*(17+12+12+27+32)=300bits

15.8

Example1 of Huffman coding

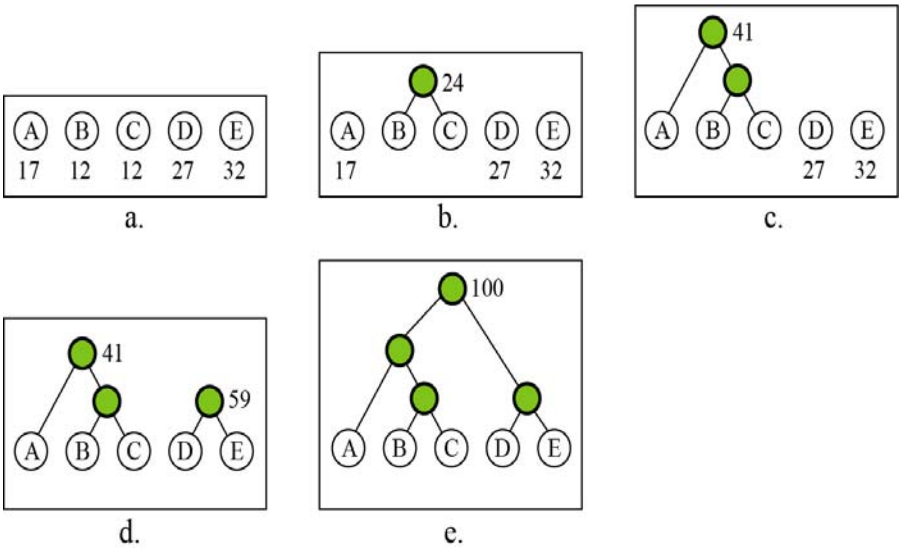
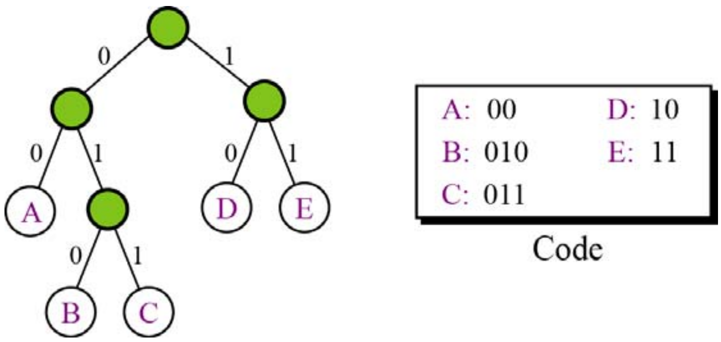


Figure 15.4 **Huffman coding**

15.9

A character's code is found by starting at the root and following the branches that lead to that character. The code itself is the bit value of each branch on the path, taken in sequence.



#bits = 2bits*(17+27+32)+3bits*(12+12)=224bits

Figure 15.5 **Final tree and code** **300bits**

15.10

Huffman Encoding

Let us see how to encode text using the code for our five characters. Figure 15.6 shows the original and the encoded text.

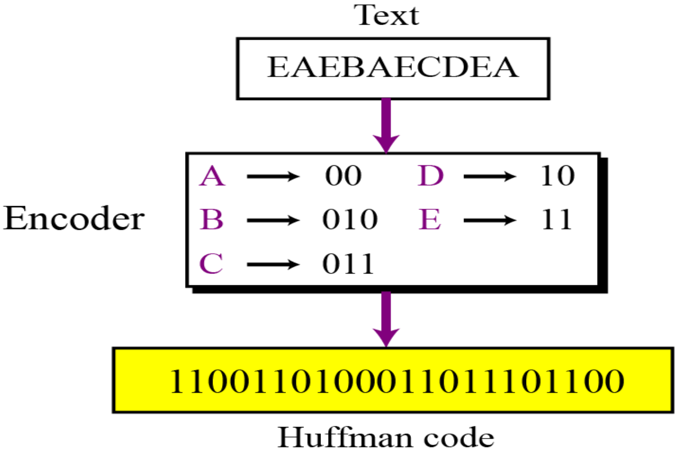


Figure 15.6 Huffman encoding

Decoding

The recipient has a very easy job in decoding the data it receives. Figure 15.7 shows how decoding takes place.

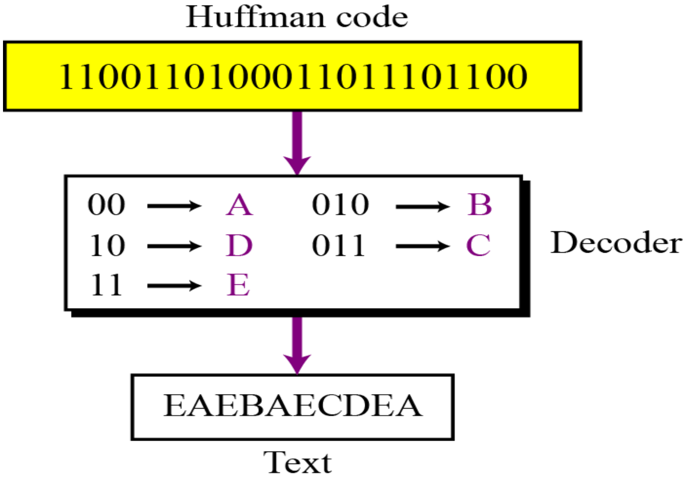


Figure 15.7 Huffman decoding

Lempel Ziv encoding

Lempel Ziv (LZ) encoding is an example of a category of algorithms called *dictionary-based* encoding. The idea is to create a dictionary (a table) of strings used during the communication session. If both the sender and the receiver have a copy of the dictionary, then previously-encountered strings can be substituted by their index in the dictionary to reduce the amount of information transmitted.

15.13

Compression

In this phase there are two concurrent events: **building an indexed dictionary** and **compressing a string of symbols**. The algorithm extracts the smallest substring that cannot be found in the dictionary from the remaining uncompressed string. It then stores a copy of this substring in the dictionary as a new entry (**ABBB**) and assigns it an index value (**6**). **Compression occurs** when the substring (**ABB**), except for the last character (**B**), is replaced with the index found in the dictionary. The process then **inserts the index (4) and the last character (B) of the substring into the compressed string**.

Example:

1	2	3	4	5	6
B	A	AB	ABB	BA	ABBB

B, A, 2B, 3B, 1A, 4B

15.14

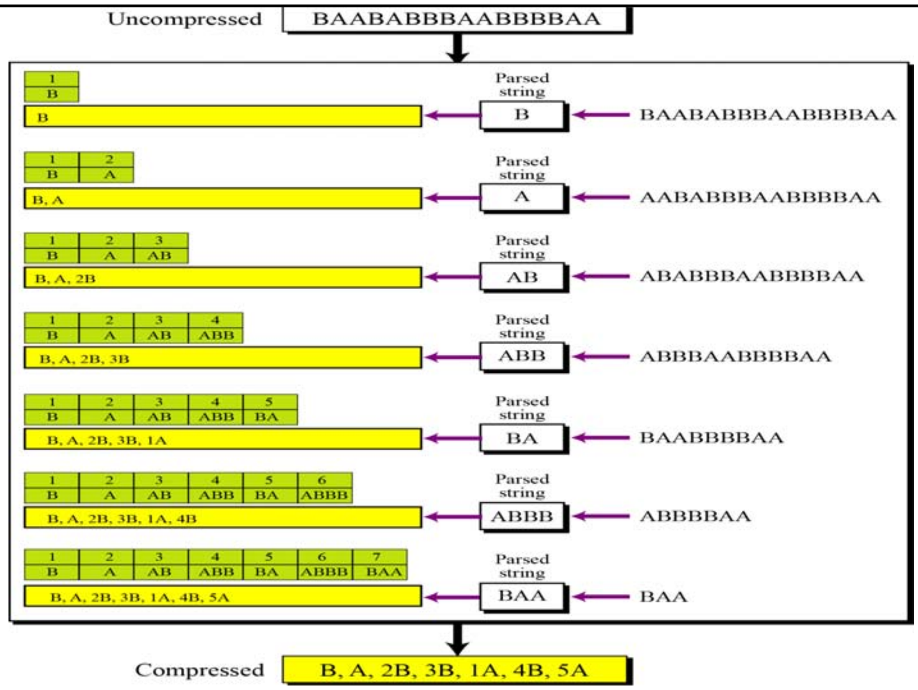


Figure 15.8 An example of Lempel Ziv encoding

15.15

Decompression

Decompression is the inverse of the compression process. The process extracts the substrings from the compressed string and tries to replace the indexes with the corresponding entry in the dictionary, which is empty at first and built up gradually. The idea is that when an index is received, there is already an entry in the dictionary corresponding to that index.

15.16

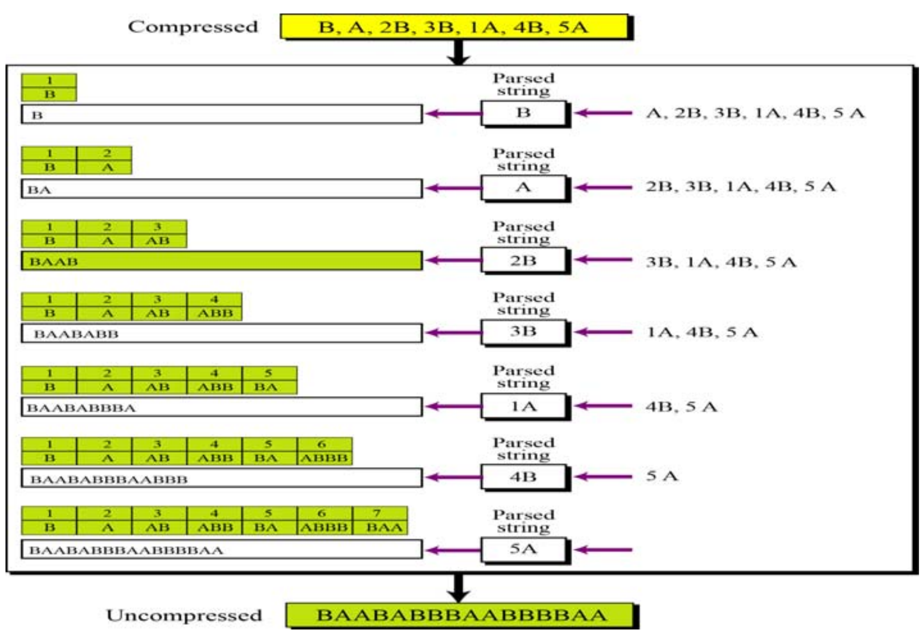


Figure 15.9 **An example of Lempel Ziv decoding**

15-2 LOSSY COMPRESSION METHODS

Our eyes and ears cannot distinguish subtle changes. In such cases, we can use a lossy data compression method. **These methods are cheaper — they take less time and space** when it comes to sending millions of bits per second for images and video. Several methods have been developed using lossy compression techniques. **JPEG (Joint Photographic Experts Group)** encoding is used to compress pictures and graphics, **MPEG (Moving Picture Experts Group)** encoding is used to compress video, and **MP3 (MPEG audio layer 3)** for audio compression.

Image compression – JPEG encoding

As discussed in Chapter 2, an image can be represented by a two-dimensional array (table) of picture elements (pixels).

A **grayscale** picture of 307,200 pixels (640*480) is represented by 2,457,600 bits (i.e., 8 bits * 307200), and a **color** picture is represented by 7,372,800 bits (i.e., 24 bits * 307200).

In JPEG, a grayscale picture is divided into blocks of **8 × 8 pixel blocks** to decrease the number of calculations because, as we will see shortly, **the number of mathematical operations for each picture is the square of the number of units**.

For the entire image of 640 * 480 pixels, required 307200^2 operations can be reduced to be $64^2*80*60 = 19660800$ operations

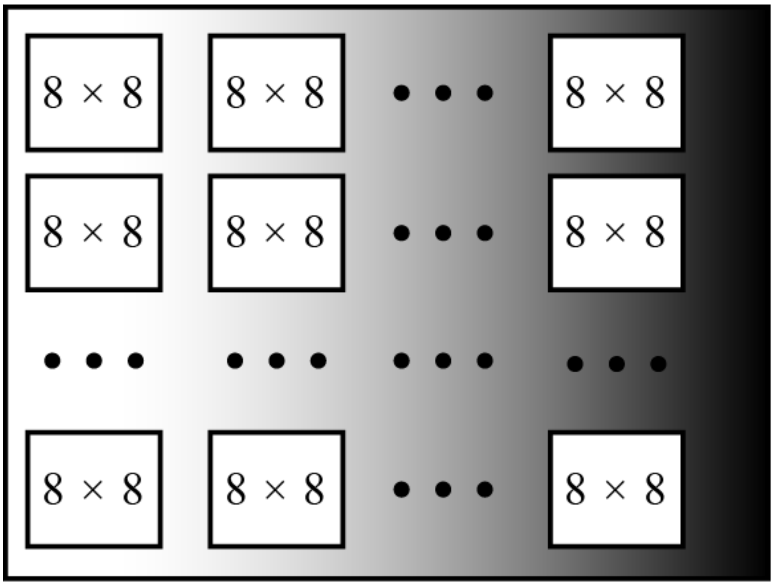
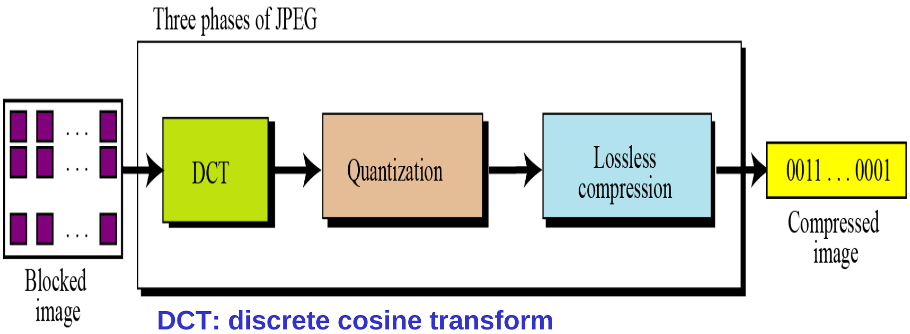


Figure 15.10 **JPEG grayscale example, 640 × 480 pixels**

The whole idea of JPEG is to **change the picture into a linear (vector) set of numbers that reveals the redundancies**. The redundancies (lack of changes) can then be removed using one of the lossless compression methods we studied previously. A simplified version of the process is shown in Figure 15.11.



DCT: discrete cosine transform

Figure 15.11 **The JPEG compression process**

Discrete cosine transform (DCT)

In this step, each block of 64 pixels goes through a transformation called the **discrete cosine transform (DCT).** The transformation **changes the 64 values so that the relative relationships** between pixels are kept but **the redundancies are revealed**.

The formula is given in Appendix G. **P(*x*, *y*) defines one value in the block**, while **T(*m*, *n*) defines the value in the transformed block**.

To understand the nature of this transformation, let us show the result of the transformations for three cases.

Case 1: Uniform grayscale

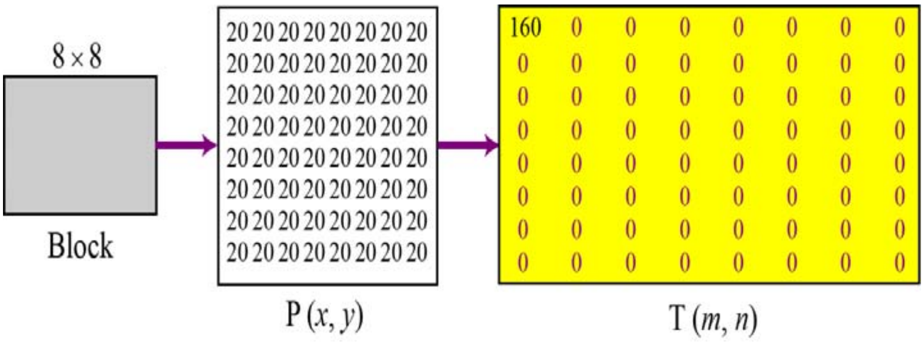


Figure 15.12 **Case 1: uniform grayscale**

Case 2: Two different uniform grayscale sections

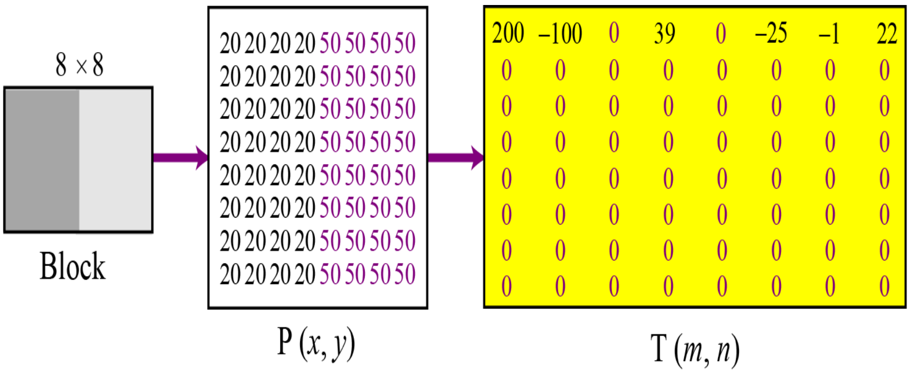


Figure 15.13 **Case 2: two sections**

Case 3: A block that changes gradually

8 × 8

Block

P(x, y):

20	30	40	50	60	70	80	90
20	30	40	50	60	70	80	90
20	30	40	50	60	70	80	90
20	30	40	50	60	70	80	90
20	30	40	50	60	70	80	90
20	30	40	50	60	70	80	90
20	30	40	50	60	70	80	90
20	30	40	50	60	70	80	90

T(m, n):

400	−146	0	−31	−1	3	−1	−8
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Figure 15.14 **Case 3: gradient grayscale**

15.25

Quantization

After the T table is created, the values are quantized to reduce the number of bits needed for encoding. **Quantization divides the number of bits by a constant and then drops the fraction**. This reduces the required number of bits even more. In most implementations, a quantizing table (8 by 8) defines how to quantize each value. The divisor depends on the position of the value in the T table. This is done to optimize the number of bits and the number of 0s for each particular application.

15.26

Compression

After quantization the values are read from the table, and redundant 0s are removed. However, **to cluster the 0s together, the process reads the table diagonally in a zigzag fashion rather than row by row or column by column**. The reason is that if the picture does not have fine changes, the bottom right corner of the T table is all 0s.

JPEG usually uses run-length encoding at the compression phase to compress the bit pattern resulting from the zigzag linearization.

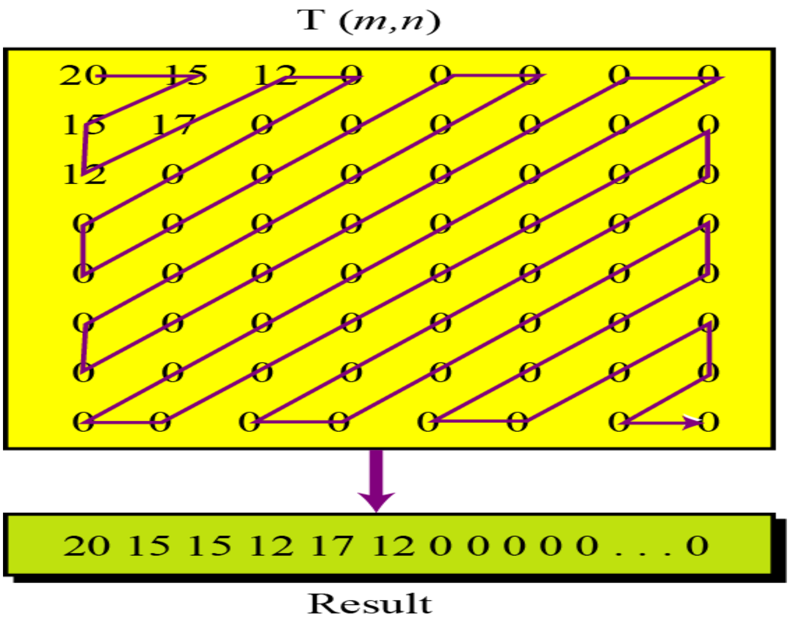


Figure 15.15 Reading the table

Video compression – MPEG encoding

The **MPEG (Moving Picture Experts Group)** method is used to compress video. In principle, a motion picture is a rapid sequence of a set of frames in which each frame is a picture. In other words, a frame is a spatial combination of pixels, and a video is a temporal combination of frames that are sent one after another. Compressing video, then, means spatially compressing each frame and temporally compressing a set of frames.

15.29

Spatial compression

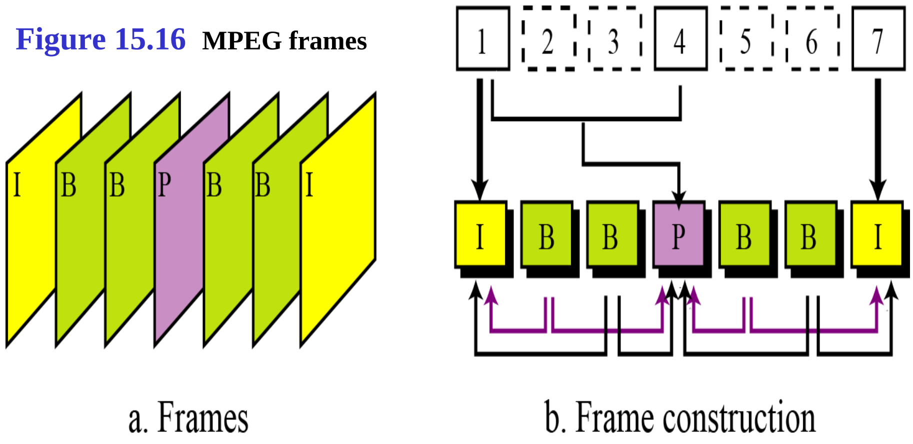
The spatial compression of each frame is done with JPEG, or a modification of it. Each frame is a picture that can be independently compressed.

Temporal compression

In temporal compression, redundant frames are removed. When we watch television, for example, we receive 30 frames per second. However, most of the consecutive frames are almost the same. For example, in a static scene in which someone is talking, most frames are the same except for the segment around the speaker's lips, which changes from one frame to the next.

15.30

Figure 15.16 **MPEG frames**



MPEG divides frames into three categories:
I-frame: ***Intracoded frame***
P-frame: ***Predicted frame is related to the preceding I-frame or P-frame.***
B-frame: ***Bidirectional frame is relative to the preceding and following I-frame or P-frame.***

Audio compression

Audio compression can be used for speech or music. **For speech we need to compress a 64 kHz digitized signal**, while **for music we need to compress a 1.411 MHz signal**.
Two categories of techniques are used for audio compression: **predictive encoding** and **perceptual encoding**.

Predictive encoding

In predictive encoding, **the differences between samples are encoded instead of encoding all the sampled values**. This type of compression is normally **used for speech**. Several standards have been defined such as GSM (13 kbps), G.729 (8 kbps), and G.723.3 (6.4 or 5.3 kbps). Detailed discussions of these techniques are beyond the scope of this book.

Perceptual encoding: MP3

The most common compression technique **used to create CD-quality audio** is based on the perceptual encoding technique. This type of audio **needs at least 1.411 Mbps**, which cannot be sent over the Internet without compression. MP3 (MPEG audio layer 3) uses this technique.

15.33

Data Encryption

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SVSD PG College Bhatoli, Distt Una, H.P.

SYMMETRIC KEY ENCRYPTION

1.6 ENCRYPTION: A DEFENSIVE SYSTEM AGAINST THREATS

Encryption ensures the confidentiality requirements of a system. Sensitive Information must travel over the public channels (such as the Internet) can be defended by the encryption, or secret codes. Information security relies heavily on encryption. The goal of encryption is to make it impossible for a hacker who obtains a cipher text (encrypted information) as it passes on the network to recover the original message. Encryption is the mutation of information in any form (text, video, and graphics) into a form readable only with the decryption key. A key is a very large number, usually a string of zeroes and ones. There are two main kinds of encryption known today: symmetric encryption and asymmetric encryption systems:

1.6.1 Symmetric Key Encryption Systems

Symmetric encryption systems, also known as secret or private key encryption systems/conventional encryption/single key encryption were the only type of encryption in use prior to the development of asymmetric key encryption systems. These types of systems rely on generating a common key called secret key for both encryption and decryption. In such a system, both the parties i.e., the transmitter and the receiver must trust each other and preserve a copy of the secret key to encrypt and decrypt the messages. They also must ensure that the key is not leaked or overheard in transmission such as local phones etc. Anyone having access to the key may misuse it for encrypting or decrypting the secret messages.

ASYMMETRIC KEY ENCRYPTION

1.6.2 Asymmetric Key Encryption Systems

Asymmetric key encryption systems are also known as Public –key encryption systems. These systems use two keys, one key to encrypt the message and the other corresponding key to decrypt the message. The two keys are mathematically related so that the data encrypted by one can be decrypted by the other. This system is based on a pair of keys one of them is known as public key which can be made public to all the users, the other key is called private key which is always kept confidential and never exposed. Both the keys should however be protected for any modifications, since keys once modified can never be further used for encryption or decryption.

Figure 1.4: Authentication in Public Key Cryptosystems

Table summarizes the main differences and the important aspects of the symmetric and Asymmetric encryption systems:

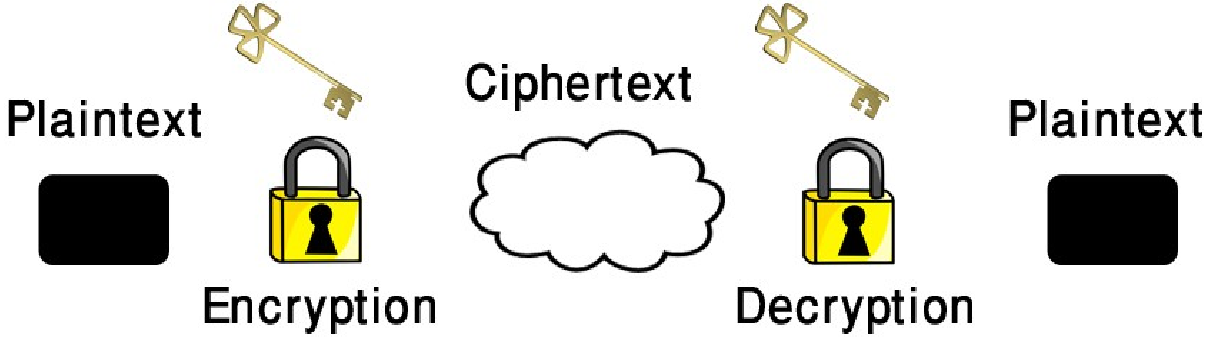
Symmetric Encryption	Public-Key Encryption
• The same algorithm with the same key is used for encryption and decryption	• One algorithm is used for encryption and decryption with a pair of keys, one for encryption and one for decryption
• The sender and the receiver must share the algorithm and the key	• The sender and the receiver must have one of the matched pair of keys(not the same one)
• The key must be kept secret	• One of the two leys must be kept secret
• It must be impossible or atleast impractical to decipher a message if no other information is available	• It must be impossible or atleast impractical to decipher a message if no other information is available
• Knowledge of the algorithm plus samples of ciphertext must be insufficient to determine the key	• Knowledge of the algorithm plus one of the keys plus samples of ciphertext must be insufficient to determine the key

DATA ENCRYPTION

- Encryption Definition:
  - The action of disguising information so that it can be recovered easily by the persons who have the key, but is highly resistant to recovery by persons who do not have the key.

DATA ENCRYPTION

- A message is cleartext (plaintext) is encrypted (disguised) through the use of an encryption key to create a Ciphertext.



DATA ENCRYPTION

- The encryption key may be changed from time to time to make an intruder's task more difficult.
- Restoration of a ciphertext to cleartext is achieved by the action of decryption using a decryption key.

DATA ENCRYPTION

- In symmetric (Single key):
  - The encryption and decryption keys are the same.

- In asymmetric (two keys):
  - The encryption and decryption keys are different.

DATA ENCRYPTION

- Encryption Methods:
  - Encryption is accomplished by scrambling the bits, characters, words, or phrases in the original message. Scrambling involves two activities:
    - Transposition
    - Substitution

DATA ENCRYPTION

- Transposition:
  - In which the order of the bits patterns, characters, words or phrases is rearranged.
- Substitution:
  - In which new bit patterns, characters, words, or phrases are substituted for the originals without changing their order.

DATA ENCRYPTION

- Data Encryption Standard (DES):
  - Most widely used algorithm
  - Pioneered by IBM
  - It is symmetric cryptosystem
  - Developed to protect sensitive, unclassified, US government, Computer data.
  - Used to provide authentication of electronic funds transfer messages.

DATA ENCRYPTION

- DES Algorithm:

  - The algorithm accepts plaintext, P, and performs an initial permutation, IP, on P producing P_0, The block is then broken into left and right halves, the Left (L_0) being the first 32 bits of P_0 and the right (R_0) being the last 32 bits of P_0.

  - With L_0 and R_0, 16 rounds are performed until L_{16} and R_{16} are generated.

  - The inverse permutation, IP^{-1}, is applied to $L_{16}R_{16}$ to produce ciphertext C.

DATA ENCRYPTION

- Public Key Cryptosystem
  - It is an asymmetric cryptosystem.
  - First announced in 1976.
  - Offer a radically different approach to encryption.
  - The idea depends on the use of a pair of keys that differ in a complementary way.
  - Several algorithms are proposed
  - RSA algorithm is considered to be highly secure.

DATA ENCRYPTION

- Public key encryption can achieved:
  - Privacy
  - Authentication

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Indian Parliament has passed the Patents (Amendment) Bill 2005 that would replace the Patents (Amendment) Ordinance 2004 earlier issued by Government of India in December 2004. The Patents (Amendment) Bill 2005 introduces product patent regime for food, chemicals and pharmaceuticals. India was required to introduce product patent protection in these sectors from 1.1.2005 in accordance with the obligation under the TRIPS Agreement of the WTO. To fulfill this requirement, Government of India had issued an Ordinance in 2004. The Ordinance was to be approved by the Parliament. While introducing the Patents (Amendment) Bill 2005 in the Parliament, Government introduced certain changes from the provisions in the Ordinance.

Salient features of the Patents (Amendment) Bill 2005

Features in the Patents (Amendment) Bill, 2005 that are same as the provisions in the Patents (Amendment) Ordinance, 2004

a) Extension of product patent protection to all fields of technology (i.e., drugs, foods and chemicals);
b) Deletion of the provisions relating to Exclusive Marketing Rights (EMRs) (which would now become redundant), and introduction of a transitional provision for safeguarding EMRs already granted;
c) Introduction of a provision for enabling grant of compulsory license for export of medicines to countries which have insufficient or no manufacturing capacity, to meet emergent public health situations (in accordance with the Doha Declaration on TRIPS and Public Health);
d) Modification in the provisions relating to opposition procedures with a view to streamlining the system by having both Pre-grant and Post-grant opposition in the Patent Office;
e) Addition of a new proviso in respect of mailbox applications so that patent rights in respect of the mailbox shall be available only from the date of grant of patent, and not retrospectively from the date of publication.
f) Strengthening the provisions relating to national security to guard against patenting abroad of dual use technologies;
g) Rationalization of provisions relating to time-lines with a view to introducing flexibility and reducing the processing time for patent applications, and simplifying and rationalizing procedures.

Important changes incorporated in the Patents (Amendment) Bill, 2005 as compared to the Patents (Amendment) Ordinance 2004

(The Bill was moved by Shri Kamal Nath, Minister of Commerce & Industry, in the Lok Sabha on 22/3/05 and in Rajya Sabha (Upper House) on 23/3/05)

1. The 2nd amendment in the Patents Act had made a provision under Section 107A (b) providing for 'parallel import'. However, this required that the foreign exporter was duly authorized by the patentee to sell and distribute the product.

In the Bill this has been amended to say that the foreign exporter need only be 'duly authorized under the law’.

Scope of patentability:

2. Modification in Section 2 – Definitions as follows:

· Section 2 (ja) "Inventive step" means a feature of an invention that involves technical advance as compared to the existing knowledge or having economic significance or both and that makes the invention not obvious to a person skilled in the art;

· New definition "New invention" means any invention or technology which has not been anticipated by publication in any document or used in the country or elsewhere in the world before the date of filing of patent application with complete specification, i.e., the subject matter has not fallen in public domain or that it does not form part of the state of the art.

· New definition "Pharmaceutical Substances" means any new entity involving one or more inventive steps.

3. Changes in Section 3:
(Section 3 lists out the exceptions to patentability, i.e., what are not considered to be inventions)

Section 3 (d): the mere discovery of a new form of a known substance which does not result in the enhancement of the known efficacy of that substance or the mere discovery of any new property or new use for a known substance or of the mere use of a known process, machine or apparatus unless such known process results in a new product or employs at least one new reactant.

Explanation to Section 3 (d): "Salts, esters, ethers, polymorphs, metabolites, pure form, particle size, isomers, mixtures of isomers, complexes, combinations, and other derivatives of known substance shall be considered to be the same substance, unless they differ significantly in properties with regard to efficacy.

4. The word "mere" introduced by the Ordinance before the words "new use" in Section 3 (d) is now deleted.

5. The clarification relating to patenting of software related inventions introduced by the Ordinance as Section 3(k) and 3 (ka) is omitted.

Strengthening of Pre-grant Opposition:

6. Opposition to grant of patent: The new Chapter heading concerning opposition, namely,

"Representation and Opposition Proceedings" is substituted with the heading, namely, "Opposition Proceedings to Grant of Patent".

7. Hearing at pre-grant opposition stage: A provision for hearing at pre-grant opposition stage has been made in the Rules. This is now introduced upfront in the law itself, as follows:

"25 (1) Where an application for a patent has been published but a patent has not been granted, any person may, in writing, represent by way of opposition to the Controller against the grant of patent within the prescribed period on the grounds of

(a) .. ……..

(b) .. ……..

and the Controller shall if requested by such person for being heard, hear him and dispose of the representation in such manner and within such period as may be prescribed.

8. Extension of time for filing pre-grant opposition: A minimum period of 6 months, from the date of publication is provided for making representation as against the present period of 3 months.

(Since all time-lines have been provided in the subordinate legislation, this will also be done in the Rules).

9. Expanding the grounds for pre-grant opposition: The grounds of pre-grant opposition in the Ordinance were novelty, inventive step and industrial applicability, non-disclosure or wrongful mentioning of source and geographical origin of biological material and anticipation of invention by knowledge, oral or otherwise, available in public domain. These are substantive grounds of opposition. Now the grounds are listed in the same way as in the Act before the Ordinance. Accordingly, in the pre-grant opposition also all the eleven grounds (formal as well as technical) are being specifically mentioned.

10. Deletion of Section 25(2): Section 25 (2) introduced by the Ordinance denies the person making an opposition representation the right of becoming a party to any proceedings under the Act. Sub-section 2 of Section 25 is deleted.

11. Facilitation of pharmaceutical exports to LDCs:

The new provision (Section 92A) relates to compulsory license for export of patented pharmaceutical products (provided for in Para 6 of Doha Declaration), to such countries, as have inadequate production capacities.

Here the condition of obtaining compulsory license is expanded, (in case of LDCs having no Patent Law or provision for compulsory license) to include an 'authorization' or notification from such a country. This is done by modifying sub-section (1) of section 92A as follows:

Adding the following words after the words "provided compulsory license has been granted by such country":

"or such country has by notification or otherwise allowed importation of the patented pharmaceutical products from India."

12. Transitional arrangement applications:

A 3rd new proviso is added under Section 11 A (7) as follows:

"Provided also that after a patent is granted in respect of applications made under sub-section (2) of section 5, the patent holder shall only be entitled to receive reasonable royalty from such enterprises which have made significant investment and were producing and marketing the concerned product prior to 1.1.2005 and which continue to manufacture the product covered by the patent on the date of grant of the patent, and no infringement proceedings shall be instituted against such enterprises."

13. Quantifying 'reasonable period' in relation to compulsory licensing:

The present Act already contains provisions under Section 84 (7) (a) (iv) whereby a compulsory license could be requested on the ground that "the establishment or development of commercial activities in India is prejudiced".

Similarly, Section 84 (6) (iv) provides that in considering an application for compulsory license the Controller of Patents is required to take into account "as to whether the applicant has made efforts to obtain a license from the patentee on reasonable terms and conditions and such efforts have not been successful within a reasonable period as the Controller may deem fit. An explanation is now incorporated to the existing Section 84 (6) (iv) for quantifying the 'reasonable period' referred to above, as under:

"Explanation: - The reasonable time period under this clause shall not ordinarily exceed six months".

14. Amendment to Section 90 relating to compulsory license:

Section 90 (1) (vii) and (viii) has been redrafted in the Ordinance. A further modification is now made to clarify that even when compulsory license is granted for pre-dominant purpose of supply in Indian market, the licensee may export the patented product, if need be; Similar facility of export is also permitted when license is granted to remedy a practice determined after judicial or administrative process to be anti-competitive.

Sub-Section (vii) and (viii) of Section 90 (1) is modified, and a new sub-section (ix) is introduced, which is as follows:

(vii) that the license is granted with a predominant purpose of supply in the Indian market and that the licensee may also export the patented product, if need be in accordance with Section 84 (7) (a) (iii); (viii) that in the case of semi-conductor technology, the license granted is to work the invention for public non-commercial use;

(ix) that in case the license is granted to remedy a practice determined after judicial or administrative process to be anti-competitive, the licensee shall be permitted to export the patented product, if need be.

The Practice of Telepathology in India

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ABSTRACT

Telepathology in India is still in the evolving stages. Although, much progress has been made around the world specially in the field of digital imaging and virtual slides, the practice of telepathology in India still revolves around static telepathology, be it in telelearning or distance learning, or in remote diagnosis. Websites such as telepathology.org.in have been very successful in popularizing telepathology through quizzes of interesting and rare cases. The only study of teleconsultation from India, has shown that a good concordance with glass slide and static telepathology images. The reasons for the relative delay in acceptance of telepathology in India are manifold.

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KEY WORDS: Acceptance, India, successes, telepathology

Telepathology is the acquisition of histological, cytological, and macroscopic images for transmission along telecommunication pathways for diagnosis, consultation, or continuing medical education. Since 1968, after the first instance of telepathology in Boston was successfully demonstrated,[1] and with the exponential growth of technology over the years, telepathology and the art of digital imaging have grown by leaps and bounds.

Telepathology may be static (store and forward), dynamic (real-time), or hybrid. Store and forward telepathology is the act of capturing images of the slide and forwarding them to a remote site. This is a less efficient method but there have been isolated reports[2] of a concordance of as high as 95–100% between glass slide and telepathology diagnosis. Store and forward telepathology has its limitations because of the disjointed nature of the images, and the diagnostic errors incurred with this method have been attributed to inappropriate field selection by the submitting pathologist.[3] Dynamic telepathology using fully motorized robotic systems, though cost-prohibitive, has revolutionized the field, and a concordance rate of 99–100% has been reported between telepathology and light microscopy diagnosis.[4,5] Hybrid systems using nonrobotic real time telepathology has had variable success rates.[6] But the most recent advances in digital imaging techniques promise to change the lifestyle of the pathologists from the microscope to the computer screen. These are the 'virtual slides' where the entire slide is scanned at a very high resolution and can be viewed by multiple pathologists[7] and without any loss of resolution.

Virtual slides are digitized slides where one is allowed see the slide in different magnifications, just like a microscope, and without the need of having multiple images. Image acquisition of an entire microscopic slide is done at all magnifications available on the microscope. The software drives the motorized stage to acquire all fields of view and then seamlessly stitches the fields into a single image. These virtual slides have extremely large file size, sometimes exceeding 1.5 GB, and hence cannot be transferred easily with the present network bandwidth limitations. Such slides are therefore stored in 'virtual slide boxes' where database storage can be done on a central server. Virtual slide viewers have been developed for use with this virtual slide database and rapid and interactive visualization with any portion of the image and at any magnification is possible.[8] The fourth generation telepathology imaging systems use miniature microscope arrays (MMAs). The output from about 100 miniaturized microscopes is simultaneously captured by 100 individual digital images.[3] The result is a virtual slide that can be produced in minutes. Such systems promise to transform histopathological laboratories in the very near future.

Digital imaging applications have come a long way to the present status. Use of modern digital cameras rather than chemical photography has the added advantages of lower running costs, early archiving, dissemination, transmission, and even the possibility of medical vision systems.[9] It also provides a tool for adjusting, enhancing, and annotating medical images.[10] Optimizing images without falsifying them using software such as Adobe Photoshop,[11] can also enhance an image to exactly what is observed on gross examination or under the microscope.

The applications of telepathology, like those of telemedicine can be broadly classified into two major groups: second opinion and distance learning. The best example of the use of telepathology for second opinion is the 'solo' pathologist who is required to be a 'specialist' in every field of pathology, which is impossible however hardworking one might be. In remote and rural areas where because of economic reasons, one cannot afford to have a competent pathologist, telepathology is considered to be a boon. The UICC has estimated that in at least 5–10% of cancer cases, a pathologist is confounded with uncertainty.[12] In this and in situations where one can consult outstanding specialists in the diagnosis of controversial cases, telepathology is the answer. Distance or telelearning in pathology has also gained acceptance. Telepathology has been used for research applications, distance education, quizzes, and online atlases with astounding success.

Telepathology in India

India was not lagging far behind in the field of telepathology. The first taste of telepathology in India was provided at a symposium organized in the 50th Annual Conference of the Indian Association of Pathologists and Microbiologists in Mumbai in 2001 aptly named Telepathology: Today and Tomorrow.[13] Since then a number of symposia and workshops held in different parts of the country have contributed to popularize this tool both at the national and the state level. A telepathology quiz page was opened in the popular pathoindia.com[14] e-group and interesting cases were put up in the form of a quiz. Some of these cases were also hosted for discussion at http://ipath.ch, which is a free site offering an open source framework for building web- and email-based telemedicine applications.[15] With the experience of pathoindia.com came telepathologyindia.com (now telepathology.org.in).[16] The use of "telepathology quizzes" with images of cases hosted at telepathology.org.in has caught the imagination of pathologists in India, both young and old. These quizzes consist of publication of a brief history of the patient and adequate diagnostic images, and invitation is sent by emails to hundreds of pathologists by the group list at pathoindia.com. Anyone can present a case, and judging from the flurry of replies one gets, this sort of telelearning is indeed very popular. Telepathology.org.in also attempted to give free consultancy service to pathologists in India. However, only about 12 pathologists from around the country and abroad have taken advantage of this service till date.

The experience of Desai et al.[17] in using static telepathology consultation between a tertiary cancer centre (Tata Memorial Hospital) and a rural cancer hospital (Nargis Dutt Memorial Cancer Hospital) in Barshi, Maharastra is an eye-opener. The authors have proved that using existing telecommunication facilities and a 56 k modem, it was possible to have good telepathology consultation and a concordance rate of 90.2% was observed. The project bore fruit after overcoming initial difficulties of 'unreliable and inconsistent' communications and through perseverance and cooperation amongst various organizations such as Department of Telecommunications (DOT), Mahanagar Telephone Nigam Limited (MTNL), and Bharat Sanchar Nigam Limited (BSNL). The experience gained can serve as a model to make telepathology a working reality in rural India. A possible way to overcome such inconsistencies in network facilities in India, is the use of web-based telepathology systems, as described by Brauchli et al.[15]

In spite of recent Government initiatives to improve the telecommunication facilities, and the necessity that is obviously there, telepathology is yet to permeate into everyday activities for pathologists in India. The reasons for this are manifold. The lack of agreement on a preferred technology and the lack of uniform standards acceptable to the pathology community have been the major factors responsible for the underdevelopment of telepathology all over the world. One major drawback in rural India is the sub-optimal preparation of slides. Images for remote diagnosis, after all, can only be as good as the original slides. A relative reason for the failure of telepathology consultation and the inability of experts to come to a conclusive diagnosis, apart from sub-optimal images, is the absence of a rapport between the sending pathologist and the consultant pathologist. The latter would rather not give a diagnosis based on images sent by a third party. This was the experience we faced in telepathologyindia.com (now telepathology.org.in). Finally, there has been a resistance from senior histopathologists in India for the promotion of telepathology. This could possibly be because of a negative preconception about telepathology. Reassurance of potential users is necessary because these perceived problems are human, rather than technological.

Conclusions

Great technological advances are taking place throughout the world in the field of telepathology. The concept of digital imaging and virtual slides has taken the world by storm. In India, telepathology is yet to take shape. Although, it has been conclusively proved that even with the existing and primitive telecommunication systems, telepathology works, even in rural areas, many factors are responsible for its delayed acceptance in India. Perseverance, cooperation and the willingness to promote telepathology seem to be the order of the day.

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CHAPTER 26

TELERADIOLOGY

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The conversion from analog to digital methods in the medical imaging world and the emergence of widely available mechanisms to quickly and affordably transmit digital data over large distances have fueled the rapid growth of teleradiology. In modern radiology departments in both the academic and private sectors it has become commonplace to select the location of a fully functioning picture and archiving communications system (PACS) workstation based on manpower and workflow considerations rather than proximity to the site of image acquisition. In addition, affordable scaled-down teleradiology solutions have allowed referring physicians and radiologists to access imaging from the convenience of their homes and offices.

This chapter summarizes some of the key issues in image acquisition, transmission, and interpretation. These summaries are followed by a discussion of the clinical practice of teleradiology, sharing knowledge gained from practical experience that can be useful in helping a teleradiology program meet its full potential. Diagrams of a typical teleradiology system are shown in Figures 26.1 and 26.2.

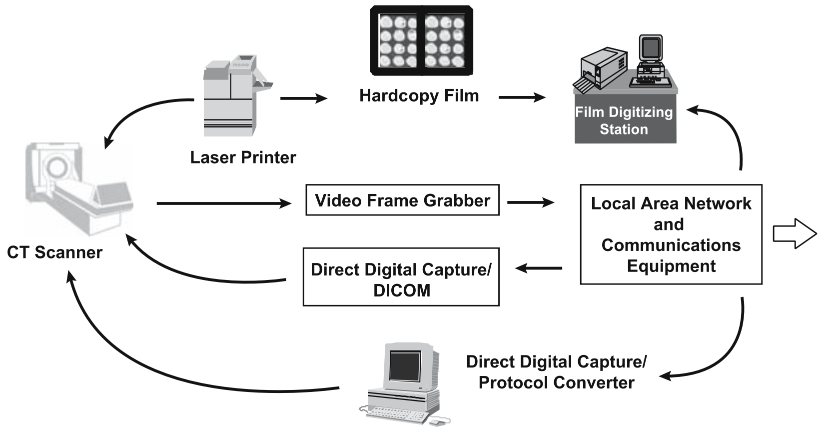

FIGURE 26.1

Schematic diagram of different approaches to image acquisiton in teleradiology.

IMAGE ACQUISITION AND IMAGE DIGITIZATION

Although any type of medical image may be transmitted by teleradiology, all images must be in a digital form before transmission can occur. Conventional hardcopy images from any modality can be digitized by special high-

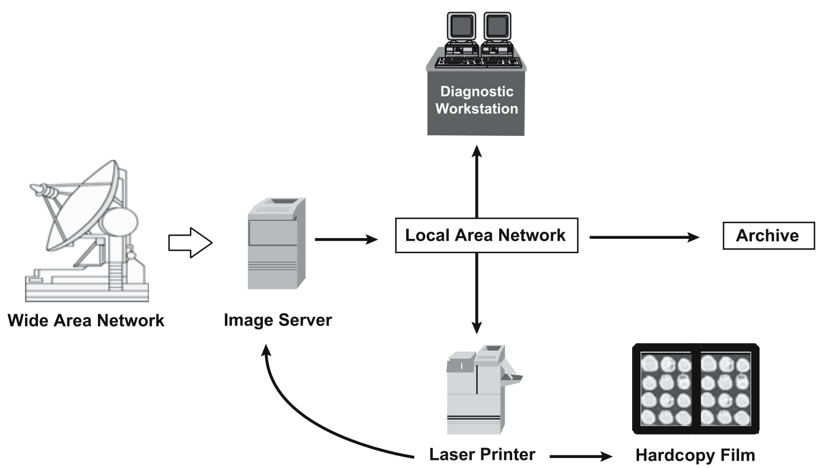

FIGURE 26.2

Schematic layout of a teleradiology interpretation site.

resolution laser or charge-coupled device (CCD) scanners (Figure 26.1). Simplistically, film scanners for teleradiology function similarly to fax machines by scanning analog data and converting it into digital form. Charge-coupled device scanners using the same technology as video cameras have tiny photocells that acquire data from a transilluminated film. Laser scanners offer better signal-to-noise ratios than CCD scanners, leading to superior contrast resolution. They are, however, more expensive. Additional studies are required to determine whether the superior contrast resolution offered by laser scanners is diagnostically significant.

Another alternative to image digitization of hardcopy films is the use of a video camera to view a film on a light box. The analog video signal can then be converted into a digital format. This approach was very common in the early days of teleradiology but has been largely abandoned due to inadequate image quality.

Many images are inherently digital: computed tomography, magnetic resonance, ultrasound, nuclear medicine, computed radiography, digital radiography, and digital fluoroscopy. All can be directly linked to a teleradiology system if they are in a standard format (Figure 26.1). Fortunately, more and more imaging devices are complying with the ACR-NEMA (American College of Radiology and National Electrical Manufacturers Association) DICOM 3 standard (Digital Imaging and Communications in Medicine—version 3). The DICOM 3 standard is important to teleradiology because a direct digital connection can be made from the image source to the teleradiology server and then from the teleradiology-receiving computer to a diagnostic workstation. Furthermore, DICOM 3 offers no loss of the full 12-bit dataset (2056 grayscales) generated from digitally acquired images, exhibits no image degradation, and has full capability to adjust image window and level settings. The DICOM 3 standard is a great step forward, although implementation of the standard is still not uniform. Some manufacturers may be DICOM compliant, but the standard allows enough flexibility that implementations can vary from one manufacturer to another. However, these incompatibilities are usually resolved with the cooperation of the respective vendors.

In practice, many digitally acquired images cannot be directly linked to teleradiology systems because they are acquired on older equipment that is not DICOM compliant. Different manufacturers of imaging equipment historically used proprietary file formats and communications protocols, which prevent direct interfacing to communications networks. These digitally acquired data need to be converted into the standard DICOM 3 format before image transmission can occur (Figure 26.1).

Various solutions are available to convert proprietary digital data into an acceptable form for transmission over a teleradiology network. One of the most commonly used methods is to simply take the hardcopy rendition of a digital modality and digitize the image with a laser or CCD digitizer. Although this is not scientifically elegant, it overcomes a number of problems. However, it is less desirable because of the image degradation that invariably occurs during an analog-to-digital conversion. Another alternative is to use a video frame grabber wherein the video signal output that is sent to an imaging console is converted to digital form (Figure 26.1). Such devices are commonly used to connect ultrasound machines to PACS, even today. It is also possible to use a protocol converter, which is a special computing device that converts proprietary image data to the DICOM 3 compliant format.

IMAGE COMPRESSION

File sizes for typical digitized medical images are large (Table 26.1). Transmission of this volume of data requires significant bandwidth (the capacity of a communication medium to carry data). Therefore, these file sizes may be too large for teleradiology to be effective, both practically and economically. To reduce the amount of digital data to be transmitted, the digital data can be compressed prior to transmission.

Table 26.2 illustrates the potential benefits of compression. Using the example of a typical radiographic exam with 4 images, the table shows that

TABLE 26.1
File Sizes for Digital Medical Images

Modality (MB)	Image Matrix	Study	Images/File Size
Mammography	2294 × 1914 × 12	4	32
Plain radiographs	2048 × 2048 × 12	4	25
Fluoroscopy	1024 × 1024 × 8	18	19
Computed tomography	512 × 512 × 12	30	12
Magnetic resonance imaging	256 × 256 × 12	100	10
Ultrasound	256 × 256 × 8	24	1.6
Nuclear medicine	128 × 128 × 8	24	0.4

TABLE 26.2
Effect on Transmission Times (minutes) of Compression for Digitized Radiographs (25 MB)

Compression Ratio	Bandwidth: 14.4 Kb/s†	28.8 Kb/s	56 Kb/s	1.45 Mb/s (T1)	155 Mb/s (ATM)
1:1	231.5	115.7	58.8	2.2	0.02
2:1	115.7	57.8	29.4	1.1	0.01
10:1	3.1	11.5	5.9	0.22	0.002
20:1	11.5	5.7	3.0	0.11	0.001
30:1	7.7	3.8	2.0	0.07	0.0006
60:1	3.8	1.9	1.0	0.04	0.0003

† Kilobits per second.

it takes 231.5 min to transmit at 14.4 Kb/s, the bandwidth of most older standard phone lines and modems. This is completely impractical, and teleradiology systems use both compression and access to higher bandwidths (Table 26.3) to reduce transmission times to manageable levels.

Compression can be “lossless” (reversible), with compression ratios typically in the range of 3 : 1, and the original dataset can be fully regenerated, or “lossy” (irreversible), where much higher compression ratios are possible. Compression ratios of at least 10 : 1 are generally required before data compression can have a significant economic effect. Although lossy compression requires some loss from the original dataset, several studies have shown that compression ratios of 20 : 1 or higher can be achieved without sacrificing diagnostic image content.

The Joint Photographics Experts Group (JPEG) standard is the most commonly employed technique, but a number of alternatives exist, including wavelets, which have proven to be a practical and powerful compression tool. Both JPEG and wavelets can be used in either a lossy or lossless mode. JPEG compression is the only technique currently supported by the DICOM 3 standard. JPEG’s principal advantages are that it is inexpensive, widely acceptable to most computing platforms, and implemented in both hardware and software. It does, however, suffer from “block artifacts” (artificial edges created between pixel blocks to which the human eye is

TABLE 26.3
Effect of Bandwidth on the Transmission Times of Medical Images

	Bandwidth				
Modality	**14.4 Kb/s***	**28.8 Kb/s**	**56 Kb/s**	**1.544 Mb/s (T1)**	**155 Mb/s (ATM)**
Plain radiographs	231.5†	115.7	58.8	2.2	0.02
Fluoroscopy	176	88	44	1.6	0.02
Computed tomography	111	55.5	27.8	1.0	0.04
Magnetic resonance imaging	94	47.5	23.5	0.9	0.01
Nuclear medicine	6.4	3.2	1.6	0.03	0.0003

* Kilobits per second.
† All transmission times in minutes.

sensitive), particularly at higher compression ratios. Wavelet compression may be advantageous at higher compression ratios, which may be required for implementation of a teleradiology system that is both practical and economical. The DICOM working group on compression (Group 4) is evaluating alternative compression techniques such as wavelets for inclusion in the standard.

A major advantage of wavelet compression over JPEG compression is that it permits substantially higher compression ratios while maintaining image quality. This has practical implications for high-volume teleradiology, particularly from international sites, where the cost of data transmission becomes a significant factor in the overall cost of the teleradiology system. Several studies have now confirmed that compression ratios of up to 20:1 are diagnostically acceptable. Film transmission times can therefore be significantly reduced, thereby permitting images to reach the referral site within a fraction of the time at significantly reduced costs (Table 26.2). Real-time teleradiology therefore becomes a reality, enabling remote consultations while the patient is still in the doctor's office or emergency room (ER) at the remote site.

Wavelet compression algorithms consist of 3 basic functions: (1) transformation, (2) quantization, and (3) lossless coding. Once discrete wavelet transformation has occurred, the image is processed using quantization, which is the lossy step in the compression algorithm. Care must be taken at this stage not to lose image quality because of the lossy step in the process. Finally, lossless coding is performed, which removes redundant information from the dataset. Once compressed, the image is transferred to the remote site, where it requires decompression before it can be interpreted. The lossless step that was performed as the last step in image compression is reversed. Quantization cannot be reversed, as it is a lossy function. Finally, the image is reconstructed using an inverse transformation process, which is then available for image interpretation.

Although image degradation occurs at higher compression ratios using wavelet compression, these artifacts produce less image degradation than JPEG artifacts at similar compression ratios. Practical image quality is maintained up to compression ratios of 20:1 and even higher.

IMAGE TRANSMISSION

Several forms of transmission media exist with different bandwidths (Table 26.3), including: conventional dial-up telephone lines (9.6 to 28.8 kilobits persecond [Kb/s]), switched digital service (56 Kb/s), frame relay (up to T1), integrated services digital network, or ISDN (128 Kb/s), T1 lines (1.54 Mb/s), digital signal level 3, or DS3 (44.736 Mb/s), and asynchronous transfer mode, or ATM (typically 155 Mb/s). Although ATM can be extremely fast, it is expensive. As broadband has penetrated the home market, most homes in the developed world can access the Internet via either digital subscriber line (DSL) over a telephone wire or over a television cable, with speeds varying from 750 Kb/s up to 10 Mb/s. However, actual transmission speeds depend on the total route the data need to travel; the longer the distance, the longer it will typically take. It also varies with the amount of competing traffic on the network segments involved. Dedicated T1 and ISDN lines are variably deployed and may be expensive for small-volume teleradiology. Ultimately, the choice of line depends on the customer's needs, the volume of studies to be transmitted, the types of studies, turnaround times, and expected peak activity. If all the images are transmitted during one period of the day, then higher bandwidth may be required. As indicated in Table 26.3, if sufficient bandwidth is available, transmission times become quite short even for uncompressed large image files.

Transmission of digitized data requires communication equipment. The nature of the equipment depends on the communication medium being used. This may be a modem for conventional telephone lines, a terminal adapter for an ISDN line, a channel service unit (CSU) for a T1 line, a DSL modem, or a cable modem.

IMAGE INTERPRETATION

Once images are received from the wide area network (WAN) at the interpretation site, they can be sent directly to an interpretation workstation or to an image server that permits distribution within the institution (Figure 26.2). Archiving or storing the images for long periods may not be required, as is necessary for PACS. Provided images are online for several days to handle delays in processing (i.e., weekends and holidays) or to respond to clinical questions pertinent to the case; longer-term storage usually is not necessary because the images are typically archived in the department of origin.

The type of monitor used to read the studies depends on whether full primary readings are being performed or the system is being used for on-call emergencies. The American College of Radiology (ACR) recommends a minimum resolution of 2000 × 2000 pixels × 12 bits for image acquisition for conventional radiographs. However, this does not mean that the monitor must be capable of displaying all the pixels of the image at once. In fact, the de facto standard in radiology departments for the display of 5-megapixel (MP) radiographs is a 3-MP display. Even on 5-MP displays, 5-MP radiographs are almost never displayed at their full native resolution. They are almost always minified to make room for other elements of the screen such as buttons and menus, and when a landscape-oriented portable chest x-ray is displayed on a portrait-oriented display (a common occurrence), the image is shrunk even more to make it fit. The requirements for teleradiology are certainly not more stringent than those used in the radiology department. However, even 3-MP monitors are expensive and may be impractical for general home use when on call. For lower-resolution images (CT, MRI, ultrasound, and nuclear medicine), 512 × 512 pixels × 8-bit resolution is adequate, for which most monitors used for home personal computers suffice.

ACCURACY OF TELERADIOLOGY

Improvements in teleradiology systems and the imperatives of contemporary medical practice have led to the widespread use of teleradiology. Two of the major concerns by early adopters have been whether radiologists would accept softcopy review of images on computer workstation screens versus traditional hard copy, and whether the accuracy of interpretation was sufficient to justify deployment of clinical teleradiology. Both questions have now been answered to variable degrees. First, radiologists have readily adapted to computer viewing to the point that many departments are using it not only for teleradiology cases but also for routine work. At Massachusetts General Hospital (MGH), substantially all modalities, including plain radiography, fluoroscopy, angiography, CT, MRI, ultrasound, and nuclear medicine, are routinely acquired, viewed, interpreted, and managed in a digital electronic environment. In most cases, hardcopy films are no longer printed, and there is a growing consensus that in many applications the ability to optimize image contrast and intensity greatly facilitates the radiologist's practice.

With respect to accuracy of interpretation of softcopy versus hardcopy, the issues are more complex. For the relatively low-resolution cross-sectional modalities, including CT, MRI, ultrasound, and nuclear medicine, the accuracy of softcopy interpretation has, for all practical purposes, not been an issue. It has not been the subject of intense clinical research investigation. Radiologists have simply switched with a collective subjective impression of equal or superior interpretive accuracy. The relatively low resolution of these studies is easily encompassed by the resolution of commonly available monitors. The ability to use flexible viewing formats, such as "stack mode," which allows the radiologist to move quickly back and forth through a series of tomographic sections, has supported the change in practice from hardcopy to softcopy viewing of these modalities. In the teleradiology application, softcopy viewing of these modalities is no different remotely than locally, once acquisition of the original digital datasets has been accomplished.

With respect to conventional radiographic images, the question of accuracy is less clear. A significant body of literature compares accuracy of interpretation of original hardcopy radiographs with digitized radiographs viewed in softcopy mode. As pointed out by Larson et al., among others, there is an inevitable loss of spatial and contrast resolution in the digitization process, with some subjective decrease in image quality. However, in their study of the sensitivity for detecting nodules, pneumothoraces, interstitial lung disease, and fractures, there were no statistically significant differences between the original hardcopy analog radiographs and the digitized images viewed on a 1280 × 1024-pixel matrix monitor equipped with an 8-bit/pixel grayscale display. An important point in Larson et al.'s study is that the overall accuracy for detection of conditions such as nodules and pneumothoraces is less than optimal in the first place, averaging 60% and 77%, respectively. These numbers are in keeping with the literature and indicate that the real issue is finding more accurate ways of detecting subtle abnormalities regardless of viewing method. Computer-assisted diagnostic techniques will probably be required to boost detection of subtle nodules and pneumothoraces from historic levels.

Another problem in assessing the accuracy of softcopy interpretation of radiographs is the low resolution and low quality of much of the equipment, including digitizers and workstations used for these analyses. For example, papers by Ackerman and Scott demonstrated statistically lower detection rates for digitized radiographs versus analog radiographs for pneumonia and fractures. However, the digitizer used in their studies had a spot size of 210 mm compared with the 100-mm spot size used in Larson et al.'s work. Also, the monitor resolution was either 1280 × 1024 or 1200 × 1600 pixels. Each of these is lower than the minimum standard recommended by the American College of Radiology of 2.5 line pairs per millimeter (lp/mm) at a 10-bit depth. This line-pair resolution requires a equates to a roughly 2000 × 2500-resolution matrix for a 14 × 17-in radiograph.

Optimistically, some studies with high-resolution monitors have demonstrated substantial equivalency between hardcopy and softcopy interpretation. Goldberg's prospective study of 685 cases of double-read softcopy and hardcopy produced overall agreement in 97% of cases without a statistical advantage for either approach. Ten cases were judged to be false negative by softcopy interpretation, 3 cases were judged to be hardcopy interpretation errors, and 1 case was unresolved as observer variation. In Rajavi's series of 239 pediatric cases, no significant difference was found between hardcopy interpretation and use of high-resolution 2000 × 2000-pixel softcopy images on a CRT monitor. The clearly agreed-upon exception to softcopy viewing is mammography, which requires higher spatial resolution than is available on current monitors.

The major problem in sorting through the literature on the accuracy of softcopy interpretation of radiographs is the lack of standardization. Digitizers of widely varying spot size and workstations with different spatial resolutions, luminosities, and functional characteristics have been used, and there is no widespread use of standard sets of reference images, making true comparisons between observers difficult. Work on defining the necessary parameters for optimal softcopy viewing continues. In the meantime, the practice of softcopy interpretation of radiographs is rapidly becoming widespread as departments of radiology become increasingly digital. There is also no question that the quality of radiographs obtained by computed radiography or direct digital capture are superior to radiographs obtained in original analog hardcopy format and secondarily digitized by a CCD or laser digitizer. The optimal configuration for teleradiology of all modalities is direct digital capture with transmission of the full digital dataset.

APPLICATIONS OF TELERADIOLOGY

Table 26.4 summarizes current clinical, research, and educational uses of teleradiology. Although exact numbers are not available, several thousand teleradiology systems are deployed in the United States. Many of these, if not the majority, are "lower end" or entry-level systems used by radiologists to provide emergency or on-call coverage for their practices. The home workstation is often a personal computer, so that CT, MRI, ultrasound, and nuclear medicine images up to 512 × 512 pixels or somewhat more can be

TABLE 26.4
Applications of Teleradiology

1. On-call coverage—Emergency/24-hour
   Hospital to home
   Inter- and intrainstitutional
2. Primary Interpretations
   Freestanding imaging centers
   Rural hospitals and clinics
   Imaging centers within regional delivery systems
   Nursing homes, other special care facilities
3. "Reverse" teleradiology
4. Second opinions/consultations
5. Access to subspecialty expertise at academic medical centers
   Domestic and international consultations
6. Image processing
7. Utilization management
8. Quality assurance
9. Overreads by second radiologist
10. Research
11. Image data collection and management
    Image analysis
12. Teaching files
13. Care presentations
14. Online journals

displayed at full resolution. These systems often allow image magnification so that plain films may be viewed at nominal full resolution according to the American College of Radiology standards, as noted. Full resolution is equivalent to roughly 2000 × 2500 pixels.

On-call applications are proving extremely valuable in the clinical practice of radiology. Radiologists are able to provide more rapid consultations than would be possible if physical travel to the hospital were required. Radiologists can cover multiple institutions simultaneously, and subspecialists within a group can provide on-call coverage more flexibly. Many teleradiology companies have formed in recent years that offer emergency radiology coverage during overnight hours and weekends. These services can help radiologists face the challenge of meeting ever-increasing on-call demands in the setting of a relative shortage of radiologists. As round-the-clock service is impractical for solo practitioners or small groups, teleradiology offers the opportunity for contemporaneous interpretation without having to be on call an undue or impractical percentage of the time.

One of the best documented teleradiology programs in the United States providing services to rural hospitals and clinics is at the University of Iowa. Franken et al., have studied patterns of use and have tried to determine what value is added by radiologists' consultation versus having studies reviewed by nonradiologists. They have confirmed that higher accuracy is achieved by radiologists. For example, in one of their teleradiology series, radiologists demonstrated a 92% versus 86% sensitivity compared with family practitioners in interpreting studies of the chest and extremities.

Another growing application of teleradiology is coverage for freestanding imaging centers, outpatient clinics, nursing homes, and smaller hospitals. In these applications, common themes are improved coverage, improved access to subspecialist radiologists, and lower cost of service provided. Using the experience with the MGH as an example, teleradiology is used for all the purposes cited. Prior to teleradiology, if a clinician in a neighborhood health center needed an immediate interpretation, films were put into a taxicab and taken to the MGH main campus. This cumbersome and expensive solution was never satisfactory and is being replaced by teleradiology, with essentially real-time, online interpretative services becoming available throughout the MGH service region. Routine interpretations from the affiliated imaging centers had been available only through batch reading of cases brought twice a day to the MGH main campus or one of the larger satellite centers. Now, every case can be read immediately by a subspecialist radiologist. The MGH experience highlights the observation that teleradiology will be used extensively by regional integrated delivery systems to improve radiology coverage.

The rapid growth in freestanding imaging centers, often dedicated to cross-sectional imaging, has provided another impetus for teleradiology. Hundreds of these centers across the country have been established by non-radiologist entrepreneurs, who then approach the radiology community for professional interpretation support. Teleradiology is an efficient way for groups of radiologists to work with these imaging centers to expand their practices and benefit from the growth in demand for imaging studies without unduly disrupting the logistics of their practices, especially in the case of hospital-based radiology groups.

A number of institutions, including MGH as well as the US military, are exploring the concept of "reverse teleradiology" by sending cases from larger centers to smaller centers. In some situations, small departments require a radiologist to do procedures or to meet requirements for direct supervision but do not generate enough work to keep them busy or justify their cost. By sending cases from busier departments, the presence of the on-site radiologist can be cost justified, with the added benefit of improving the quality of care offered at the smaller location. At MGH, this model provides coverage for a series of high-tech imaging centers that the department has established in the community surrounding Boston. This allows the department to place a staff radiologist at each location without loss of productivity.

Teleradiology also provides access to subspecialty expertise at academic medical centers or to second opinions and consultations among larger radiology groups. This practice is growing both domestically and internationally and is being highly influenced by the Internet. Patients, physicians, third-party payers, and government agencies all need second opinions from time to time. Web sites on the Internet are being established to solicit and accommodate these opinions. In other cases, academic practices, larger radiology groups, and commercial enterprises dedicated to teleradiology are making their services available for second opinions and consultations.

The increasing importance of image post-processing suggests another application of teleradiology that has been used in the early days of CT and may become common. Smaller facilities without on-site access to three-dimensional rendering software or personnel with image-processing expertise can readily access both via teleradiology. Multisite institutions send image sets to central processing.

The possibility for radiology groups to help each other in their quality assurance programs is another potential use of teleradiology. In this model, a statistical sampling of cases from 1 group can be sent to another group via teleradiology for a quality assurance overread. This model is also useful for helping radiology groups initiate services in a new modality. For example, if a group that has not provided MRI services begins doing so, as they come up to speed they can use teleradiology to send cases to a more experienced group for an overreading function. This was a common practice in the early days of MRI, although the cases were often sent as hard copy.

Research and educational applications of teleradiology are less well publicized than direct clinical applications. The radiology department at MGH has used teleradiology to manage clinical trials in which imaging is an important part of the data collection. This application is likely to grow dramatically with the increased use of imaging-based surrogate endpoints in drug trials and the establishment of the ACRIN (American College of Radiology Imaging Network) by the American College of Radiology for the purpose of organizing clinical trials aimed at assessing the efficacy of imaging technologies.

Educational applications of teleradiology are burgeoning over the Internet. Many academic departments have Web sites with extensive teaching files. These files are often augmented by case presentations. Some sites offer radiologists the opportunity for online continuing medical education credits. The American Board of Radiology is exploring the possibility of administering its certifying examinations electronically. Major journals have extensive Web sites providing a range of services for their subscribers and even for nonsubscribers, and it is likely that the applications of remote education will become among the most prevalent uses of teleradiology.

MEETING THE GOALS OF TELERADIOLOGY

Ultimately, the purpose of off-site image interpretation is to provide better and faster delivery of patient care. When organizing a teleradiology program, it is important to take the necessary steps to ensure that this objective is met and that referring physicians, imagers, and patients are highly satisfied.

SPEED

The ability to quickly move images from place to place lends itself to the provision of fast and responsive imaging interpretation. The implementation of a teleradiology program should be associated with improved delivery of services by those who utilize radiology most frequently.

A prerequisite for fast report turnaround times is the ability of the radiologist to access images quickly. This is crucial for teleradiologists providing emergency coverage. An appropriate compression mechanism and degree should be chosen to maximize speed of transmission without diminishing practical image quality. The range of size of the typical exam files that will be sent should be taken into account. This can be dependent on the type of scanners utilized by a particular practice, as new, multislice CT scanners can generate very large datasets. The teleradiology system should be tested in advance at the site in which it will be stationed using the workstation and bandwidth connection that will be utilized. Testing should be done during the same time of day that the system will be used, as this can have a significant effect on speed at both the sending and receiving sites when certain Internet connectivity options are employed.

For the truly emergent patients it is very helpful to have a system that allows the radiologist to see the images as they are being downloaded locally onto a workstation. Some systems allow lower-resolution images to be visualized almost immediately while the case is in the process of downloading. This allows the radiologist to quickly visualize a crucial finding such as a ruptured aortic aneurysm in seconds and begin to take the necessary steps to ensure that prompt care is provided to the patient. It avoids the frustration of staring at a blank computer screen while a case is being transmitted after having been told by a technologist or trauma surgeon that a patient may have a critical finding.

Also important in emergency teleradiology is the ability to choose the parts of a case to download preferentially. In the age of multislice CT scanning, it is not uncommon to have a study that contains 750 or more images. If transmission speed is at all an issue given a particular bandwidth connection, it can be critically important to be able to download standard images in a single plane without waiting for the entire study to arrive. In this way a radiologist can begin to interpret an exam and spot most of the important findings during the time that images in multiple additional planes and specialized algorithms and delayed images are being downloaded in the background. Furthermore, a single computer error is less likely to stop the entire lengthy process and leave an interpreter without any images to view.

Speed can also be enhanced using a system that can be configured to display the most recently completed examinations at the top of a patient list. This allows a radiologist to begin to access a study before a technologist even notifies him or her of the case. In some settings this can save a significant amount of time. In the emergency setting, technologists should be encouraged to communicate with the radiologist as soon as there is a new study to be read and not wait to batch studies. Batching studies can be particularly troubling when using a teleradiology system that allows just 1 exam to be transmitted at a time. These steps can avoid the uncomfortable phone call from a technologist informing the radiologist that there are 3 patients' studies to be read and there is an ER physician demanding results on the first patient, who returned from the CT scanner over an hour ago.

The ability to download multiple cases in parallel is an important component of a teleradiology system for workflow and patient care issues. At the worst end of the spectrum are systems that allow for the download of only 1 series of 1 study at a time. This means that only after reviewing the axial images of a cervical spine CT can a radiologist request the saggital or coronal reconstructions and wait for them to arrive. Only at the completion of this process can the next trauma patient's exam be requested. An old exam likewise cannot be retrieved or reviewed simultaneously with a current exam on these systems. In practice, this will decrease the number of cases that will be compared to old exams and could impact negatively on patient care. In sharp contrast, other teleradiology systems are available that can download multiple exams or components of exams at the same time. On some of these systems, old exams and old reports are easy to locate and can be synchronized by table position with a current study for convenient comparison.

In choosing a mechanism to secure patient information and the hospital's network, it is important to balance security concerns with issues of speed and reliability. Cumbersome access mechanisms with frequent automatic terminations may provide security at the cost of valuable minutes in report turnaround times and more frequent downtimes. It is important to work closely with the information technology department to ensure adequate security, while at the same time allowing for convenient, reliable, and fast access by the teleradiologist.

MANPOWER

Manpower is perhaps the most critical component for the consistent delivery of timely care. This can be relatively easy to calculate for elective imaging needs, but quite difficult for emergency coverage. By its very nature, emergency radiology comes in bursts. Maintaining the manpower requirements to provide immediate attention to potentially critical patients during these bursts can be very inefficient for the vast majority of time when the ER pace is not as frenzied. This can be true for small departments where even a single radiologist is not needed for most of the overnight hours and for larger departments where a single radiologist may have difficulty keeping up during the busiest spurts, but 2 radiologists would be unnecessary for the vast majority of the time.

Efficiency and responsiveness could be optimized if radiologists interpreting elective cases could be quickly recruited for emergency work when needed. Though this is typical for many practices during the daytime, it can be highly impractical for most departments to achieve 24 hours per day. Over the last several years, some radiology practices have made this happen by using teleradiology to its full advantage. These practices have made the night shift attractive by establishing an office in an exotic or otherwise desirable part of the world where it is daytime during the overnight hours at the local hospital. Experts in emergency radiology modalities voluntarily relocate or rotate to this office for blocks of time while maintaining an affiliation with the home practice.

Newly formed teleradiology companies offer radiology departments the ability, in effect, to hire the portion of a dedicated night radiology workforce that they need. Ideally, this workforce should be composed of experts in ER radiology working with a schedule or in a location that is conducive to their being rested and alert. A potential disadvantage of this type of arrangement is the perception amongst colleagues of having "outsourced" the undesirable portion of the radiologists' responsibilities. Additionally, studies done overnight are interpreted by radiologists unfamiliar to the referring doctors. These disadvantages can be overcome, however, if there is adequate communication between the night radiologists and the referring doctors and if higher-quality reports can be generated with faster turnaround times.

RELATIONSHIPS WITH COLLEAGUES

The knowledge that radiologists are working from home or from a beachfront office in Hawaii does not necessarily impart an endearing first impression to nonradiologists that spend long hours each day in hospital wards. To maximize the success of a teleradiology practice, it is imperative to provide these doctors with benefits that they would not have expected from their radiology departments prior to the implementation of teleradiology. In an elective setting this can be done by maximizing the percentage of studies that are read by subspecialist radiologists. In an emergency setting, increased availability of a radiologist during off-hours will be appreciated. In many departments, referring physicians have grown accustomed to the limited availability of an on-call radiologist. Emergency room physicians quickly learn to appreciate having a radiologist colleague that is freely available for consultation, protocol questions, report clarifications, and interpretations of timelier follow-up examinations. Faster report turnaround times that can be facilitated with the use of voice recognition technology or on-site transcription will be welcomed in any clinical setting. Outpatient doctors that begin to receive same-day reports from subspecialists on patients sent to an imaging center and ER physicians that start to get head CT results before their patients return from the scanner are more likely to write complimentary letters to a radiology chairman than to be bothered by where a radiologist may sitting while the images are being interpreted.

Teleradiology should not result in weaker relationships between radiologists and colleagues in other fields. If referring physicians do not see a teleradiologist's face, effort should be made to ensure that they recognize their teleradiologist's voice and personality. In addition to the usual phone calls for unexpected or emergent findings, teleradiologists should consider other occasions to call the ordering doctors such as for interesting cases or for follow-up. Relationships build confidence, which is critical for any radiology department. This can also help improve the clinical histories that are made available for the teleradiologist and increase the amount of times that meaningful follow-up is received.

PATIENT CARE

The benefits of teleradiology that result in better service will by their nature impact patient care. Ultimately, it is the patients who benefit most by having their imaging interpreted by a subspecialist. In many instances, teleradiology has put an end to common practices that used to be quite difficult for many patients. For instance, a modern teleradiology program should guarantee that ER patients no longer have to lie for hours in cervical spine collars waiting for their spine imaging to be reviewed by a radiologist in the morning. In the not-too-distant past this was a common occurrence in many community hospitals because it was difficult to quickly move large radiological examinations from place to place. In the most emergent settings, a well-run teleradiology practice will ensure that a radiologist is immediately available to turn his or her full attention to patients who have sustained significant trauma or present for other critical indications.

Night call has often been considered by many to be the least desirable part of a radiologist's practice. Many departments demand that all full-time members share this responsibility equally. This can mean that subspecialized radiologists who do not routinely interpret important emergency imaging modalities such as CT in the daytime are forced to provide coverage for these modalities at night. With no backup readily available, vital decisions on ER and trauma patients must be made by these radiologists all night long. Transmitting images to ER radiology experts who are in favorable time zones or are working dedicated shifts can greatly improve nighttime coverage. This can also prevent having an important patient examination sent to be read by a radiologist who was just woken from sleep after having worked the previous 18 hours.

The capabilities of the teleradiology system can also have a surprisingly important impact on the quality of patient care. When making purchasing decisions it can be easy to reason that one will be able to make do with certain inconveniences while off-site. While this may be true for very low-volume practices, this is certainly not the case for busy ones. There are systems currently in use that require a combination of greater than 10 mouse clicks and button pushes to change from a standard to a subdural window. Over time, patient care will likely be compromised if a radiologist begins thinking in the midst of a busy stream of pending studies that standard brain windows are probably adequate in order to avoid the time and loss of concentration needed to change windows. If a teleradiology system is not capable of calculating a region of interest (ROI) measurement, it is extremely difficult to expect that a radiologist will telephone a technologist to have this done as frequently as may be appropriate. Similarly, features that are available but are clumsy or inconvenient may not be utilized as often as needed. A good system should give the radiologist the ability to easily window/level, change between frequently used preset values, and electronically measure, cross-reference, magnify, and synchronize images for easy comparison.

Redundancy in a teleradiology system is crucial to minimize downtime and delays in patient care. Alternate options should be considered for each component of a teleradiology system, including computers, monitors, power sources, phone lines, fax machines, and Internet connectivity at both the sending and receiving sites. If downtime does occur, a backup plan should be in place to get the images as quickly as possible to a radiologist who can interpret them before there is any negative outcome for the patient or dissatisfaction from the referring physician.

In the current market, there are affordable teleradiology systems and adequate bandwidth options that allow off-site radiologists to rapidly and reliably access high-quality, convenient-to-manipulate images. These readily available technologies will facilitate the realization of the many potential benefits of bringing radiological examinations to radiologists that are alert and expert in the type of modality or body system being imaged.

JOB SATISFACTION

Working off-site can add many administrative steps to a radiology operation. Hiring adequate support staff to assist the radiologist is an essential component of a busy teleradiology practice. Receipt of information on cases to be read, transcription, faxing reports to appropriate destinations, and logging patient information are functions that can be shared by support personnel and facilitated by available technologies. Minimizing the amount of time that a radiologist's attention is diverted from radiology to administration can maximize both quality of patient care and job approval. Teleradiology has great potential to increase the level of career satisfaction for many radiologists. Subspecialists can more easily dedicate themselves to their subspecialties. Consultation on difficult or interesting cases is possible even for radiologists who primarily work alone or geographically far from subspecialists. Radiologists wishing to work off-hours or to work from home can more easily do so. Radiologists wanting to travel can live in almost any location around the world. These many advantages may entice some of the more talented medical students into exploring radiology as a career choice, ultimately strengthening the future of the field.

LEGAL AND SOCIOECONOMIC ISSUES

Table 26.5 lists legal and socioeconomic issues affecting telemedicine. Most of these are still unresolved to variable degrees.

LICENSURE AND CREDENTIALLING

A conflict between, on the one hand, the ability of teleradiology and other telemedicine services to transcend geographic barriers technologically and,

TABLE 26.5
Legal and Socioeconomic Issues

1. Medical licensure and credentialing
2. Malpractice insurance coverage
3. Jurisdictional control over malpractice suits
4. Confidentiality of medical records
5. Physician-patient relationship
6. Technical and clinical practice standards
7. Reimbursement by third parties
8. Turf issues among radiologists

on the other, the legal responsibilities of medical licensing authorities within individual states has increased. Both the American Medical Association and the American College of Radiology have adopted policies that recommend full licensure in states where teleradiology or other forms of telemedicine are practiced. The ACR policy says, "[S]tates and their Medical Board should require a full and unrestricted medical license in the state in which the examination originates, with no differentiation by specialty, for physicians who wish to regularly practice telemedicine." This means that a physician must be licensed in both the state of his or her residence and in the other state where the image originated. Many states have either passed legislation or implemented rulings by state medical boards to this effect. These laws and rulings are summarized in Chapter 8. Requirements for full licensure are pending in several additional states, and a number of states are considering a limited license or registration program, with the proviso that the provider physician be licensed in another state. The Federation of State Medical Boards favors special-purpose licensure providing telemedicine services.

In addition to licensure, most hospitals require teleradiology providers to apply for staff credentials. The new Joint Commission on Accreditation of Healthcare Organizations (JCAHO) guidelines have a provision allowing hospitals to use telemedicine services of physicians that are credentialed at a distant site that is JCAHO certified even if they are not credentialed at the originating site. It is not yet clear how many hospitals will feel comfortable enough using the services of physicians that they have not credentialed to take advantage of this provision.

MALPRACTICE INSURANCE COVERAGE

Radiologists providing teleradiology services must have malpractice insurance that will extend coverage to lawsuits brought in all of the states in which they are providing coverage. As noted by Berlin, it is an established legal principle that the state in which the injury occurs and that has the greatest connection to the injury possesses jurisdiction over the lawsuit. Unfortunately, many malpractice insurers have regional limitations on their coverage. These have been set up due to the difficulties in defending a lawsuit in a remote location where the insurance company does not have relationships with malpractice attorneys that will defend the case and where the defending physician may be seen as an outsider. In addition, the current malpractice climate has turned many regions into very difficult malpractice environments that carriers are reluctant to become involved in. For these reasons, a radiologist practicing in many different states will often have to turn to excess and surplus-lines carriers, which can be very expensive. Furthermore, radiologists practicing outside of the United States may face additional difficulty finding malpractice carriers that have confidence that an overseas radiologist will return to the state of origin to properly defend a possible lawsuit. As the field of teleradiology continues to advance and malpractice risk levels become clarified, it is likely that insurers will gain enough comfort to respond to the unique coverage needs of teleradiology.

PATIENT CONFIDENTIALITY

Ensuring patient confidentiality is of utmost importance, and formal procedures for doing so have been mandated with the passing of HIPAA (Health Insurance Portability and Accountability Act) legislation by congress. This legislation provides guidelines for the protection of patient privacy that hospitals, imaging centers, and doctors must adhere to. For teleradiology, the image-compression process encrypts the image in a way that prevents casual theft, and Internet-based systems can be protected using virtual private networks or secure sockets layer technology. With a secure mechanism for image transmission in place, a teleradiology office must take the usual steps for patient privacy that other medical offices would take.

STANDARDS

As noted in the telemedicine report to Congress from the US Department of Commerce, there are no specialty-generated technical standards, protocols, or clinical guidelines for telemedicine, with the exception of the ACR, which has developed practice guidelines for teleradiology. The American Medical Association, the American Telemedicine Association, and a number of other professional societies are currently developing practice standards for telemedicine. The Department of Commerce report also notes that the Food and Drug Administration (FDA) is the lead federal agency with responsibility for ensuring the safety and effectiveness of telemedicine devices marketed in the United States.

The ACR has deemed that several criteria in the teleradiology process should meet minimum standards. (The ACR guidelines are included as an appendix to this chapter.) It would be prudent for anyone providing teleradiology services to review the ACR standards. Highlights from the guidelines include:

- For small matrix studies (e.g., CT, MRI, ultrasound, nuclear medicine, digital fluorography, and digital angiography), $512 \times 512 \times$ 8-bit acquisition datasets should be used; for large matrix images (e.g., conventional radiographs), datasets should be a minimum of 2.5 lp/mm at a minimum 10-bit depth.
- Minimum display resolution is not specified, although the display device should be capable of displaying all acquired data. This does not mean that the entire image needs to be able to be displayed at full native resolution, but rather that the software allows the user to zoom and pan the image sufficiently to view any part of an image at its native resolution. Thus a 3-MP display used for radiography in regular PACS workstations can certainly be used for teleradiology. The same would apply for 1–2-MP displays that are used for small matrix studies (nonradiography).
- Image annotation (patient demographics and examination information) should be included.
- Image display stations should provide functionality for window width and level settings, inverting contrast, image rotation, measurement function, and magnification.
- Display brightness of at least 50 foot-lamberts should be achieved.
- Compression ratios should be displayed with the image (no specification for what type or level of compression).
- Reasonable measures must be taken to protect patient confidentiality.

REIMBURSEMENT

There has been fairly uniform recognition of teleradiology for reimbursement by private insurance companies and government programs including Medicare and Medicaid. The exception to this is for interpretations rendered outside the United States, for which Medicare will not pay. Some private insurers have followed Medicare on this issue as well. The ACR task force on international teleradiology put out a report in April 2004 recognizing that there is no inherent technological difference between teleradiology interpretations generated in the United States and those generated outside the United States. This task force felt that payment for international teleradiology reports is appropriate provided that the following criteria are met:

1. The person interpreting the examination and submitting the report to the referring physician are one and the same.
2. The person rendering the report is licensed in the state and credentialed as a member of the medical staff at the institution performing the examination and receiving the report.
3. The person performing the interpretation and rendering the report is available for consultation.
4. The report meets the guidelines for diagnostic reports as promulgated by the ACR.
5. The ACR Technical Standard for Teleradiology is met.

Despite the ACR recommendations, it remains to be seen whether Medicare will alter its policy. In the meantime, the ACR report also indicated that it is unethical for a radiologist who did not personally interpret the images in a study to sign his or her name to a report in a manner that would indicate that this radiologist interpreted the study.

TURF ISSUES

The radiology community is divided on the issue of teleradiology. Although the general concept has been widely embraced throughout different practice settings—from the largest academic institutions to solo practitioners in private practice—the practice of teleradiology continues to create controversy. Some people in the radiology community have expressed concern that larger groups, including academic medical centers, will use their financial resources, prestige, and clout to invade the turf of smaller groups, who regard their geographic service area as inviolable. In defending this view, the point is made that it is important for radiologists to provide more than just interpretations and to take part in the medical life of the respective hospital or healthcare community. Counterarguments include the view that teleradiology provides patients and their attending physicians the opportunity to access more highly subspecialized experts than may be available in the local community, and that it is not appropriate for individual radiologists to stand between the patient and such expert opinions.

It is far from clear how the issues of mistrust and suspicion on the part of community radiologists versus the desire of larger subspecialist groups to offer their expertise more broadly will be resolved. However, one opportunity open to community radiologists is to come together among themselves to form larger networks in which individuals can begin to subspecialize and, as discussed above, where smaller groups can provide coverage to one another for a variety of purposes. The one thing abundantly obvious in the Internet age is that patients will increasingly expect electronic access when they see it as beneficial to their interests and needs. Doctors, including radiologists, will be ill-served to stand in the way of that new and increasing imperative.

CONCLUSION

Teleradiology has transitioned from its infancy and is no longer a technological curiosity. It is already part of daily practice. It is here, it works, and it will have an enduring role in shaping the future of radiology. It is likely that, in less than a decade, the term “teleradiology” will be obsolete for the simple reason that remote interpretations and consultations will be such an integral part of radiology practice that referring to them will neither require nor occasion a special term.

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APPENDIX

ACR STANDARD FOR TELERADIOLOGY

ACKNOWLEDGMENT

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Revised 1998 (Res. 35)
Revised 2002 (Res. 11) Effective 1/1/03

ACR TECHNICAL STANDARD FOR TELERADIOLOGY PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the American College of Radiology cautions against the use of these guidelines in litigation in which the clinical decisions of a practitioner are called into question. The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the guidelines, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the guidelines when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations on available resources or advances in knowledge or technology subsequent to publication of the guidelines. However, a practitioner who employs an approach substantially different from these guidelines is advised to document in the patient record information sufficient to explain the approach taken. The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. It should be recognized; therefore, that adherence to these guidelines will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of these guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION AND DEFINITION

Teleradiology is the electronic transmission of radiologic images from one location to another for the purposes of interpretation and/or consultation. Teleradiology may allow more timely interpretation of radiologic images and give greater access to secondary consultations and to improved continuing education. Users in different locations may simultaneously view images. Appropriately utilized, teleradiology may improve access to radiologic interpretations and thus significantly improve patient care. Teleradiology is not appropriate if the available teleradiology system does not provide images of sufficient quality to perform the indicated task. When a teleradiology system is used to render the official interpretation,[1] there should not be a clinically significant loss of data from image acquisition through transmission to final image display. For transmission of images for display use only, the image quality should be sufficient to satisfy the needs of the clinical circumstance.

This standard defines goals, qualifications of personnel, equipment guidelines, licensing, credentialing, liability, communication, quality control, and quality improvement for teleradiology. While not all-inclusive, the standard should serve as a model for all physicians and healthcare workers who utilize teleradiology. A glossary of commonly used terminology (not reprinted here) and a reference list are included.

II. GOALS

Teleradiology is an evolving technology. New goals will continue to emerge. The current goals of teleradiology include:

- **A.** Providing consultative and interpretative radiologic services.
- **B.** Making radiologic consultations available in medical facilities without on-site radiologic support.
- **C.** Providing timely availability of radiologic images and image interpretation in emergent and nonemergent clinical care areas.

[1] The ACR Medical Legal Committee defines official interpretation as that written report (and any supplements or amendments thereto) that attach to the patient's permanent record. In healthcare facilities with a privilege delineation system, such a written report is prepared only by a qualified physician who has been granted specific delineated clinical privileges for that purpose by the facility's governing body upon the recommendation of the medical staff.

D. Facilitating radiologic interpretations in on-call situations.

E. Providing subspecialty radiologic support as needed.

F. Enhancing educational opportunities for practicing radiologists.

G. Promoting efficiency and quality improvement.

H. Providing interpreted images to referring providers.

I. Supporting telemedicine.

J. Providing supervision of off-site imaging studies.

III. QUALIFICATIONS OF PERSONNEL

The radiologic examination at the transmitting site must be performed by qualified personnel trained in the examination to be performed. In all cases this means a licensed and/or registered radiologic technologist, radiation therapist, nuclear medicine technologist, or sonographer. This technologist must be under the supervision of a qualified licensed physician.

It is desirable to have a Qualified Medical Physicist and/or image management specialist on site or as consultants.

A. PHYSICIAN

The official interpretation of images must be done by a physician who has:

1. An understanding of the basic technology of teleradiology, its strengths and weaknesses (as well as limitations), and who is knowledgeable in the use of the teleradiology equipment.
2. Demonstrated qualifications as delineated in the appropriate American College of Radiology (ACR) guidelines or standards for the particular diagnostic modality being transmitted through teleradiology.

B. RADIOLOGIC TECHNOLOGIST, RADIATION THERAPIST, NUCLEAR MEDICINE TECHNOLOGIST, OR SONOGRAPHER

The technologist, therapist, or sonographer should be:

1. Certified by the appropriate registry and/or possess unrestricted state licensure.
2. Trained to properly operate and supervise the teleradiology system.

C. QUALIFIED MEDICAL PHYSICIST

A Qualified Medical Physicist is an individual who is competent to practice independently in one or more of the subfields in medical physics. The ACR considers that certification and continuing education in the appropriate subfield(s) demonstrate that an individual is competent to practice one or more of the subfields in medical physics and to be a Qualified Medical Physicist. The ACR recommends that the individual be certified in the appropriate subfield(s) by the American Board of Radiology (ABR).

The appropriate subfields of medical physics for this standard are Therapeutic Radiological Physics, Diagnostic Radiological Physics, Medical Nuclear Physics, and Radiological Physics.

The continuing education of a Qualified Medical Physicist should be in accordance with the ACR Practice Guideline for Continuing Medical Education (CME).

D. IMAGE MANAGEMENT SPECIALIST

1. The image management specialist is an individual who is qualified to assess and provide problem-solving input, initiate repair, and coordinate system-wide maintenance programs to assure sustainable high-image quality and system function. This individual would also be directly involved with any system expansion programs.

2. This specialist should be available in a timely manner in case of malfunction to facilitate return to optimal system functionality.

IV. EQUIPMENT SPECIFICATIONS

Specifications for equipment used in teleradiology will vary depending on the individual facility's needs, but in all cases it should provide image quality and availability appropriate to the clinical need.

Compliance with the ACR/NEMA (National Electrical Manufacturers Association) Digital Imaging and Communication in Medicine (DICOM) standard is strongly recommended for all new equipment acquisitions, and consideration of periodic upgrades incorporating the expanding features of that standard should be part of the continuing quality improvement program.

Equipment guidelines cover two basic categories of teleradiology when used for rendering the official interpretation: small matrix size (e.g., computed tomography [CT], magnetic resonance imaging [MRI], ultrasound, nuclear medicine, digital fluorography, and digital angiography) and large matrix size (e.g., digital radiography and digitized radiographic films).

Small matrix: The data set should provide a minimum of 512 × 512 matrix size at a minimum 8-bit pixel depth for processing or manipulation with no loss of matrix size or bit depth at display.

Large matrix: The data set should allow a minimum of 2.5 lp/mm spatial resolution at a minimum 10-bit pixel depth.

A. ACQUISITION OR DIGITIZATION

Initial image acquisition should be performed in accordance with the appropriate ACR modality or examination guideline or standard.

1. DIRECT IMAGE CAPTURE The entire image data set produced by the digital modality in terms of both image matrix size and pixel bit depth, should be transferred to the teleradiology system. It is recommended that the DICOM standard be used.

2. SECONDARY IMAGE CAPTURE

a. Small matrix images: Each individual image should be digitized to a matrix size as large as or larger than that of the original image by the imaging modality. The images should be digitized to a minimum of 8 bits pixel depth. Film digitization or video frame grab systems conforming to the above specifications are acceptable.

b. Large matrix images: These images should be digitized to a matrix size corresponding to 2.5 lp/mm or greater, measured in the original detector plane. These images should be digitized to a minimum of 10 bits pixel depth.

3. GENERAL REQUIREMENTS At the time of acquisition (small or large matrix), the system must include annotation capabilities including patient name, identification number, date and time of examination, name of facility or institution of acquisition, type of examination, patient or anatomic part orientation (e.g., right, left, superior, inferior), and amount and method of data compression.

The capability to record a brief patient history is desirable.

B. COMPRESSION

Data compression may be used to increase transmission speed and reduce storage requirements. Several methods, including both reversible and irreversible techniques, may be used, under the direction of a qualified physician, with no reduction in clinically significant diagnostic image quality. The types and ratios of compression used for different imaging studies transmitted and stored by the system should be selected and periodically reviewed by the responsible physician to ensure appropriate clinical image quality.

C. TRANSMISSION

The type and specifications of the transmission devices used will be dictated by the environment of the studies to be transmitted. In all cases, for official interpretation, the digital data received at the receiving end of any transmission must have no loss of clinically significant information. The transmission system shall have adequate error-checking capability.

D. DISPLAY CAPABILITIES

Display workstations used for official interpretation and employed for small-matrix and large-matrix systems should provide the following characteristics:

1. Luminance of the gray-scale monitors should be at least 50 foot-lamberts.
2. Lighting in the reading room that can be controlled to eliminate reflections in the monitor and to lower the ambient lighting level as much as is feasible.
3. Capability for selecting image sequence.
4. Capability of accurately associating the patient and study demographic characterizations with the study images.
5. Capability of window and level adjustment, if those data are available.
6. Capability of pan and zoom functions.
7. Capability of rotating or flipping the images provided correct labeling of patient orientation is preserved.

8. Capability of calculating and displaying accurate linear measurements and pixel value determinations in appropriate values for the modality (e.g., Hounsfield units for CT images), if those data are available.
9. Capability of displaying prior image compression ratio, processing, or cropping.
10. The following elements of display:
    a. Matrix size.
    b. Bit depth.
    c. Total number of images acquired in the study.
    d. Clinically relevant technical parameters.

When the display systems are not used for the official interpretation, they need not meet all the characteristics listed above.

E. ARCHIVING AND RETRIEVAL

If electronic archiving is to be employed, the guidelines listed below should be followed:

1. Teleradiology systems should provide storage capacity sufficient to comply with all facility, state, and federal regulations regarding medical record retention. Images stored at either site should meet the jurisdictional requirements of the transmitting site. Images interpreted off-site need not be stored at the receiving facility, provided they are stored at the transmitting site. However, if the images are retained at the receiving site, the retention period of that jurisdiction must be met as well. The policy on record retention must be in writing.

2. Each examination data file must have an accurate corresponding patient and examination database record that includes patient name, identification number, examination date, type of examination, and facility at which examination was performed. It is desirable that space be available for a brief clinical history.

3. Prior examinations should be retrievable from archives in a time frame appropriate to the clinical needs of the facility and medical staff.

4. Each facility should have policies and procedures for archiving and storage of digital image data equivalent to the policies for protection of hard-copy storage media to preserve imaging records.

F. SECURITY

Teleradiology systems should provide network and software security protocols to protect the confidentiality of patients' identification and imaging data consistent with federal and state legal requirements. There should be measures to safeguard the data and to ensure data integrity against intentional or unintentional corruption of the data.

G. RELIABILITY AND REDUNDANCY

Quality patient care may depend on timely availability of the image interpretation. Written policies and procedures should be in place to ensure continuity of teleradiology services at a level consistent with those for hard-copy imaging studies and medical records within a facility or institution. This should include internal redundancy systems, backup telecommunication links, and a disaster plan.

V. LICENSING, CREDENTIALING, AND LIABILITY

Physicians who provide the official interpretation of images transmitted by teleradiology should maintain licensure as may be required for provision of radiologic service at both the transmitting and receiving sites. When providing the official interpretation of images from a hospital, the physician should be credentialed and obtain appropriate privileges at that institution. These physicians should consult with their professional liability carrier to ensure coverage in both the sending and receiving sites (state or jurisdiction).

The physician performing the official interpretations is responsible for the quality of the images being reviewed.[2]

Images stored at either site should meet the jurisdictional requirements of the transmitting site. Images interpreted off-site need not be stored at the receiving facility, provided they are stored at the transmitting site. However,

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[2] The ACR Rules of Ethics state: "it is proper for a diagnostic radiologist to provide a consultative opinion on radiographs and other images regardless of their origin. A diagnostic radiologist should regularly interpret radiographs and other images only when the radiologist reasonably participates in the quality of medical imaging, utilization review, and matters of policy which affect the quality of patient care."

if images are retained at the receiving site, the retention period of that jurisdiction must be met as well. The policy on record retention should be in writing.

The physicians who are involved in practicing teleradiology will conduct their practice in a manner consistent with the bylaws, rules, and regulations for patient care at the transmitting site.

VI. DOCUMENTATION

Communication is a critical component of teleradiology. Physicians interpreting teleradiology examinations should render reports in accordance with the ACR Practice Guideline for Communication: Diagnostic Radiology.

VII. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION CONCERNS

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education Concerns appearing elsewhere in the ACR Practice Guidelines and Technical Standards book.

Any facility using a teleradiology system must have documented policies and procedures for monitoring and evaluating the effective management, safety, and proper performance of acquisition, digitization, compression, transmission, archiving, and retrieval functions of the system. The quality control program should be designed to maximize the quality and accessibility of diagnostic information.

A test image, such as the SMPTE test pattern, should be captured, transmitted, archived, retrieved, and displayed at appropriate intervals, but at least monthly, to test the overall operation of the system under conditions that simulate the normal operation of the system. As a spatial resolution test, at least 512 × 512 resolution should be confirmed for small-matrix official interpretation, and 2.5 lp/mm resolutions for large-matrix official interpretation.

As a test of the display, SMPTE pattern data files sized to occupy the full area used to display images on the monitor should be displayed. The overall SMPTE image appearance should be inspected to assure the absence of gross artifacts (e.g., blurring or bleeding of bright display areas into dark areas or aliasing of spatial resolution patterns). Display monitors used for primary interpretation should be tested at least monthly. As a dynamic range test, both the 5% and the 95% areas should be seen as distinct from the respective adjacent 0% and 100% areas.

The use of teleradiology does not reduce the responsibilities for the management and supervision of radiologic medicine.

CHAPTER 5

THEORY AND TYPES OF ANTENNAS

5.1 Introduction

Antenna is an integral part of wireless communication systems, considered as an interface between transmission line and free space [16]. Antenna converts Electrical signals into Electromagnetic signals and vice versa. It is also defined as a transducer [17].

Antenna has been around the world for more than hundred years. The first successful demonstration of Electromagnetic wave was done by Faraday around 1830's [74]. He placed a magnet through the coils of a wire attached to a Galvanometer. When he moved the magnet, he was able to produce time varying magnetic field. It in turn, had a time varying Electric Field which was detected by galvanometer. The concept of electromagnetic wave was not known to the world at that time.

In 1886, Hertz developed a wireless communication kit in which an electric spark occurred in the gap of a dipole antenna. He used a loop antenna as a receiver and observed similar effect.

Wireless Communication over long distance was first demonstrated by Marconi. He demonstrated Electromagnetic wave propagation across Atlantic Ocean. His transmitter was placed at Poldhu, UK and his receiver was placed at St. Johns, New Foundland, USA. For a transmit antenna, he used several vertical wires attached to ground. The antennas used in this experiment were of 45 meters height [73]. As operating frequency was in LF range, height of the antennas was longer which put difficulty in installing the antenna. But later on with the introduction of modulation techniques, the height of the antenna became smaller and it was easy to install antennas with manageable height.

In 1906, Columbia University had a wireless station where they used a transmitting aerial cage. This was made up of wires and suspended in the air.

In 1913, the Eiffel Tower was used as an antenna. At that time, communication was carried out at very low frequencies, the antennas had to be very large to radiate or receive properly. The Eiffel Tower fit this bill well, and was used to communicate with the United States Naval Observatory in Arlington, Virginia.

In 1890's, there were only few antennas in the world. Most of those antennas are placed at the laboratories. They were used to do experiments on Electromagnetic Waves. By World War II, the importance of Antenna was understood by the military people and also by the common man for entertainment purpose. The birth of Radio and later on Television made the industry to think on various antennas. The antenna has become an integral part of common man from that point onwards.

Fig 5.1 Prof. Yagi carrying yagi – uda antenna

Yagi – Uda Antenna is still considered as one of the easiest and efficient directional antennas to construct. It was first developed in 1929 by Shintaro Uda in Japan. The work was presented in English by Yagi, who was Uda's professor. So, this antenna has been widely known as Yagi – Uda Antenna. A picture of Prof. Yagi carrying the antenna is shown in Fig 5.1.

Horn Antennas are developed in 1939. They operate at UHF and higher frequencies. They have directional radiation pattern with gain ranging 10 to 20 dB. E – plane Horn, H – plane Horn and pyramidal Horn are the types of horn antennas which are vastly used. Horn Antennas have wide bandwidth.

Antenna Arrays were first constructed in 1940's. Arrays are combination of two or more similar antennas to increase the gain and directivity. By changing the phase of the feeding signal, it is possible to change the direction of radiation pattern of the array. This is known as phased array. Smart antenna which works based on the weighed inputs is also an array antenna. Digital Signal Processing [DSP] algorithms decide the amplitude and phase of the signal, fed to various elements of the array. Phased array and smart antennas are latest additions to the antenna fold.

Corner reflector, Parabolic reflector and Lens antennas are basically known as reflector type antennas. Parabolic Reflector which is considered the best antenna to communicate with the satellites was invented in 1940's. This antenna has wide bandwidth and very high gain of 30 to 40 dB. Either a horn antenna or a dipole is used as the feed antenna.

The Mobile phone market developed rapidly over the years with cost effectiveness of both mobile phones and service providers. Mobile phones change the life style of common man. Nowadays, almost each and every person is carrying at least an antenna which is integrated in his mobile phone.

The famous Patch Antenna was first fabricated in 1970's. Their low weight, low cost and smoothness to handle made them hot favorites for the modern applications. Patch antennas are used in mobile phones to make it compact. Planar Inverted 'F' Antenna which is also known as 'PIFA' was first developed around 1980's and this has been widely used in Laptops nowadays.

Current research focuses on making antennas smaller, particularly in communications for personal wireless communication devices such as cell phones. A lot of work is being performed on numerical modeling of antennas, so that their properties can be predicted before they are fabricated and tested. Method of Moments, Finite Element Methods, Finite Difference Time Domain method are few numerical techniques used to analyze antennas.

The Current research on antenna also involves meta-materials which are materials having a negative index of refraction. They are also known as Frequency Selective surfaces [FSS] which remove a particular frequency band from their operation.

Small, weight less antennas are used in Radio Frequency Identitification [RFID]. This type of antenna is also used at nodes of Wireless Sensor Networks [WSN].

5.2 Basic Antenna Theory

An antenna is made up of simple current carrying conductor which is radiated under certain conditions.

For wire antenna, the basic equation of radiation is expressed as

$$\boxed{\dot{I} L = Q \dot{v} \quad (\text{A m/s})} \qquad --- \qquad (5.1)$$

Where,

$\dot{I}$ = time varying current

L = length of antenna element in meter.

Q = charge in the wire.

$\dot{V}$ = time change of velocity which equals the acceleration of the charge in m/s^2.

As per equation 5.1, to create radiation, there must be a time varying current or acceleration (or deceleration) of charge. The direction of radiation is perpendicular to the acceleration, and the radiated power is proportional to the square of ($\dot{I}l$) or ($Q\dot{v}$).

If the antenna is made up of small current elements, the overall effect at a distance point is due to the integration of all the current components. The current density at the antenna results in vector magnetic potential represented as A(z). The magnetic flux density 'B' is found out with the equation

$$B = \nabla \times A \qquad \text{--- (5.2)}$$

Here '∇' represents curl operation. Once magnetic field is known, the corresponding electric field can be calculated using intrinsic impedance. Thus, the fields of the resultant EM wave can be found out using vector magnetic potential.

5.3 Antenna Parameters

An antenna's performance is measured with several critical parameters. These are resonant frequency, impedance, gain, radiation pattern, polarization, efficiency and bandwidth. Transmit antennas may also have a maximum power rating and receive antennas differ in their noise rejection properties. All of these parameters can be measured through various techniques.

5.3.1 Resonant frequency

The "resonant frequency" is related to the electrical length of an antenna. Typically an antenna is tuned for a specific frequency and is effective for a range of frequencies that are usually centered on that resonant frequency.

The length of an antenna is designed in terms of wavelength of operation. The frequency and wavelength are related as

$$\lambda = C/ f \qquad \text{----} \quad (5.3)$$

In the above equation, 'λ' is the operating wavelength, 'f' is the frequency and 'C' is the velocity of free space.

For a half wave dipole antenna, the length is '$\lambda/2$'. Similarly a monopole antenna has a length of '$\lambda/4$'. Thus the wavelength of operation determines the parameters of antenna.

5.3.2 Directivity

'Directivity' is considered as the ability of the antenna to focus its energy in a particular direction when it is transmitting and to receive energy better from a particular direction when it is receiving.

Directivity is defined as the ratio of the maximum power density to its average value over a sphere as observed in the far field of an antenna.

If the beam area is smaller, the directivity is larger. For an antenna that radiates over only half a sphere the beam area is 2π steradian and the directivity is 2 [17].

5.3.3 Gain

Gain as a parameter measures the efficiency of a given antenna. Gain and directivity of an antenna are related with antenna efficiency factor.

$$G = kD \qquad \text{--- (5.4)}$$

Where, 'G' is the gain of the antenna,

'D' is the directivity of the antenna

'k' is the antenna efficiency factor, $0 \leq k \leq 1$.

Gain can be measured by comparing the maximum power density of the antenna under test [$P_{max(test)}$] with a reference antenna of known gain [$P_{max\ (ref)}$] [17].

$$G = [P_{max(test)} / P_{max\ (ref)}] \times G_{(ref)} \qquad \text{--- (5.5)}$$

High-gain antennas have the advantage of longer range and better signal quality, but must be aimed carefully in a particular direction. Low-gain antennas have shorter range, but the orientation of the antenna is relatively inconsequential. For example, a dish antenna on a spacecraft is a high-gain device that must be pointed at the planet to be effective, whereas a typical Wi-Fi antenna in a laptop computer is low-gain, and as long as the base station is within range, the antenna can be in any orientation in space.

The gain is measured with reference to a dipole [dBd] or a theoretical isotropic radiator [dBi]. In practice, the half-wave dipole is taken as a reference instead of the isotropic radiator. The gain is then given in dBd (decibels over dipole). 0 dBd is equated as 2.15 dBi.

5.3.4 Radiation pattern

The radiation pattern of an antenna is a graph which shows the variation in actual field strength of electromagnetic field at all points which are at equal distances from the antenna. If the radiation is expressed in terms of field strength (E), it is known as ‘field pattern’. If it is given in power, then it is denoted as ‘power pattern’.

Radiation pattern is generally a three dimensional one. They are following spherical coordinate system. Certain methods are followed to represent radiation pattern into two dimensional patterns. Two dimensional patterns are drawn as elevation and azimuthal patterns, vertical and horizontal patterns, ‘E’ plane and ‘H’ plane patterns.

5.3.5 Impedance

Antenna as a transmitter is connected at the last part of a communication system. Antenna provides a series resistance to the communication network. This resistance is known as the radiation resistance. For a dipole, radiation resistance is 73 Ω.

As signal from source travels through different parts of the communication system, it may encounter differences in impedance. At each interface, depending on the impedance match, some fraction of the wave's energy will reflect back to the source, forming a standing wave in the transmission line. The ratio of maximum power to minimum power of the wave can be measured and is called the standing wave ratio (SWR). A SWR of 1:1 is ideal. It means the entire power is radiated through antenna. Practically, part of transmitted power gets reflected back into the transmission line and is measured as SWR. A SWR of 1.5:1 is considered to be acceptable. Matching impedances at each interface reduces SWR and maximize power transfer through each part of the communication system.

5.3.6 Efficiency

Efficiency of an antenna is defined as the ratio of power actually radiated to the total input power into the antenna terminals.

$$\text{Efficiency} = \frac{R_r}{R_r + R_l} \qquad \text{---- (5.6)}$$

Where, ‘R_r’ is the radiation resistance,

‘R_l’ is the ohmic loss resistance of antenna conductor.

Radiation in an antenna is caused by radiation resistance. Ohmic loss resistance usually results in heat rather than radiation, and reduces efficiency.

5.3.7 Bandwidth

The bandwidth of an antenna is the range of frequencies over which it is effective. It is centered on the resonant frequency. The bandwidth of an antenna may be increased by several techniques, including using thicker wires, replacing wires with cages to simulate a thicker wire, tapering antenna components and combining multiple antennas into a single assembly.

5.3.8 Polarization

The polarization of an antenna is defined as the orientation of the electric field (E-plane) of the EM wave with respect to the direction of EM wave. There are two types of polarizations available. They are linear and elliptical. A special case of elliptical polarization is known as circular polarization. Elliptical polarization has its sense as ‘right handed’ and ‘left handed’. To communicate signal effectively, both transmitter and receiver should have the same polarization.

5.4 Transmission and Reception

Antenna exhibits same properties when it works as transmitter as well as receiver. If an antenna has a gain of 6 dB when it works as transmitting antenna, it has the same 6 dB gain even when it works as receiver. Thus Antenna is said to have reciprocity property.

5.5 Types of Antennas

Based on the structure of antennas, they classified into the following types:

i. Wire Antennas – Dipole, Loop
ii. Aperture Antennas – Horn Antenna
iii. Reflector Antennas – Parabolic and Corner reflector antennas
iv. Array Antennas – Yagi - Uda
v. Patch Antennas – Micro strip antenna

Depends on the radiation pattern, antennas are generally fall into two categories:

i. Directional
ii. Omni directional.

Omni directional antennas radiate RF energy equally in all horizontal directions which covers 360 degrees. It is also called 'Non-Directional' as it does not prefer any direction. Fig. 5.2 shows an omni directional antenna and fig 5.3 gives the radiation pattern of omni directional antenna. The radiated signal has equal strength in all directions.

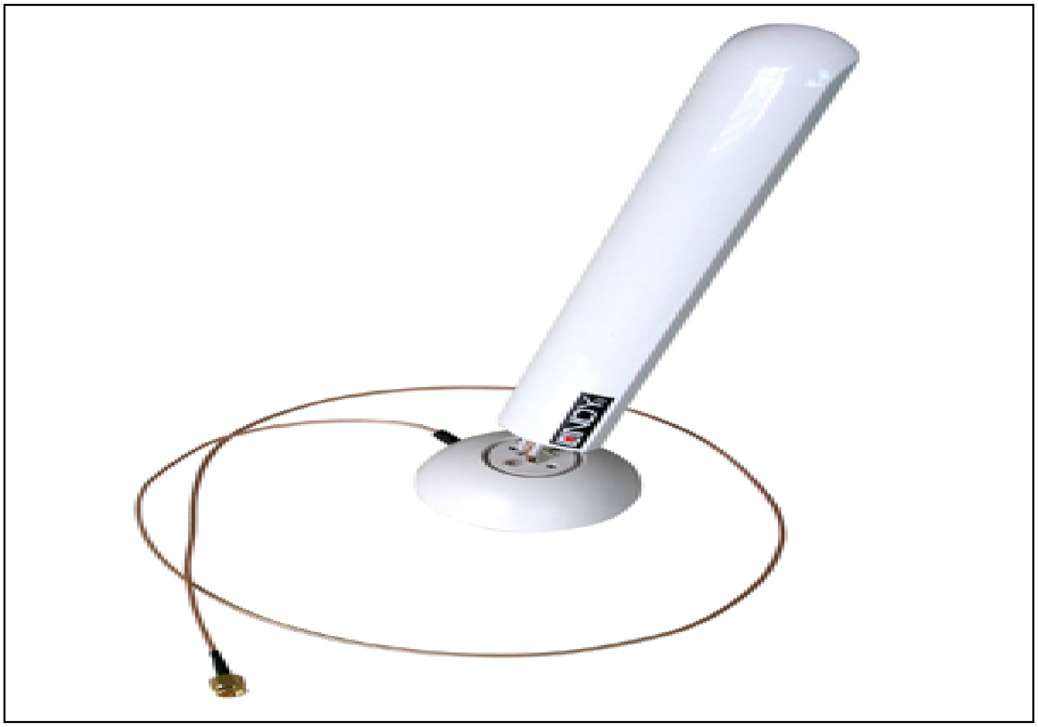


Fig 5.2. Omni Directional Antenna for WLAN.

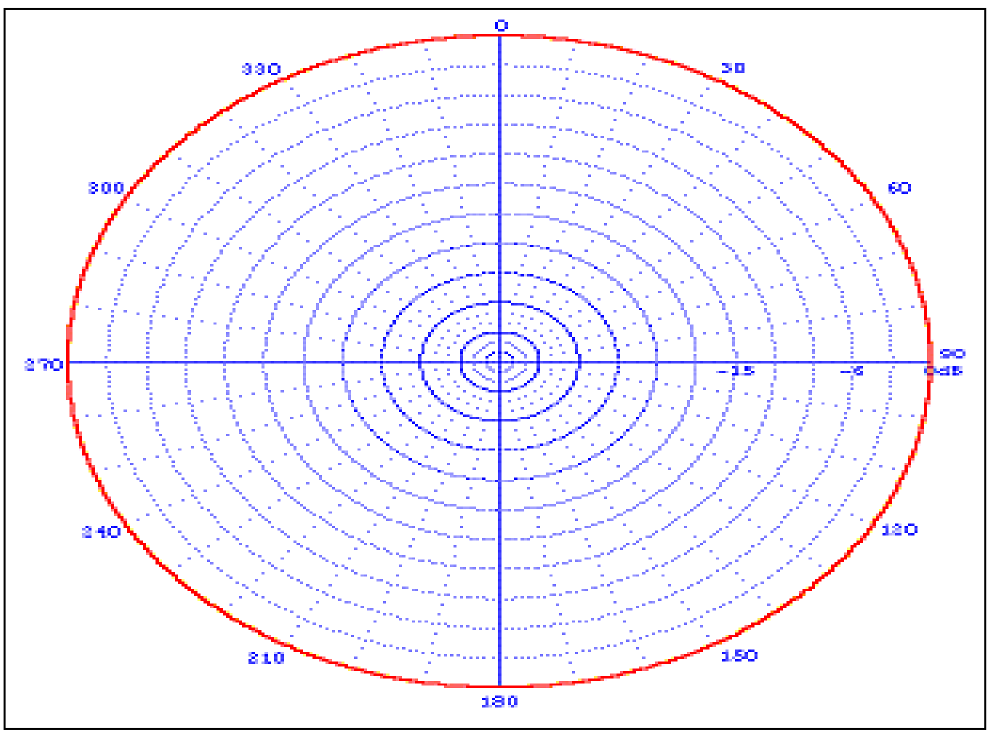


Fig 5.3 Omni Directional Radiation Pattern

5.5.1 Wire Antennas

Dipole is one of the simplest examples of directional antennas. The dipole is also known as ‘Half Wave Dipole’ as the physical length of the antenna is half of the wavelength of operation. The diagram of a half way dipole is shown below.

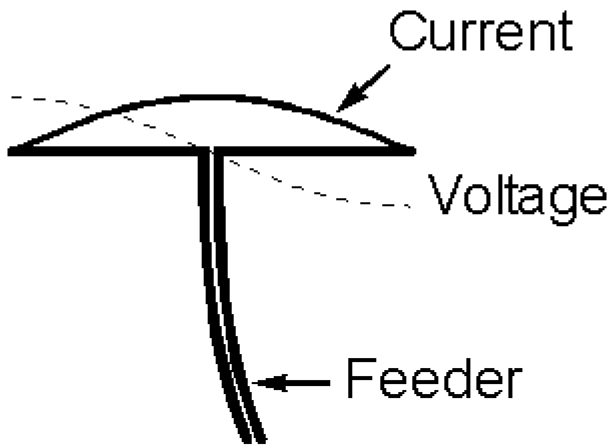


Fig. 5.4. The structure of the dipole

The frequency and wavelength of a signal are related as

$$f = C / \lambda \qquad \text{--- (5.7)}$$

Where ‘λ’ is the wavelength, ‘C’ is the velocity of free space [3×10^8 m/sec] and ‘f’ is the frequency of operation. For a frequency of 300 MHz, the wavelength is 1 meter. The half wavelength is 0.5 meter. This is the length of the dipole antenna which can operate at 300 MHz.

Half wave dipole antenna has half cycle of current distribution. Maximum of the current is at the perpendicular direction and the current reduces to ‘zero’ at both the edges of antenna. So, the radiation pattern of a dipole is having maxima at the perpendicular direction and the minima at the antenna axis ends.

The radiation pattern of the dipole is known as 'cardiod' shape. The two dimensional vertical cut of this three dimensional pattern is called as 'Figure of Eight' pattern. The radiation pattern of a half wave dipole is shown in the following diagram as a three dimensional case. The corresponding two dimensional diagram is also given below.

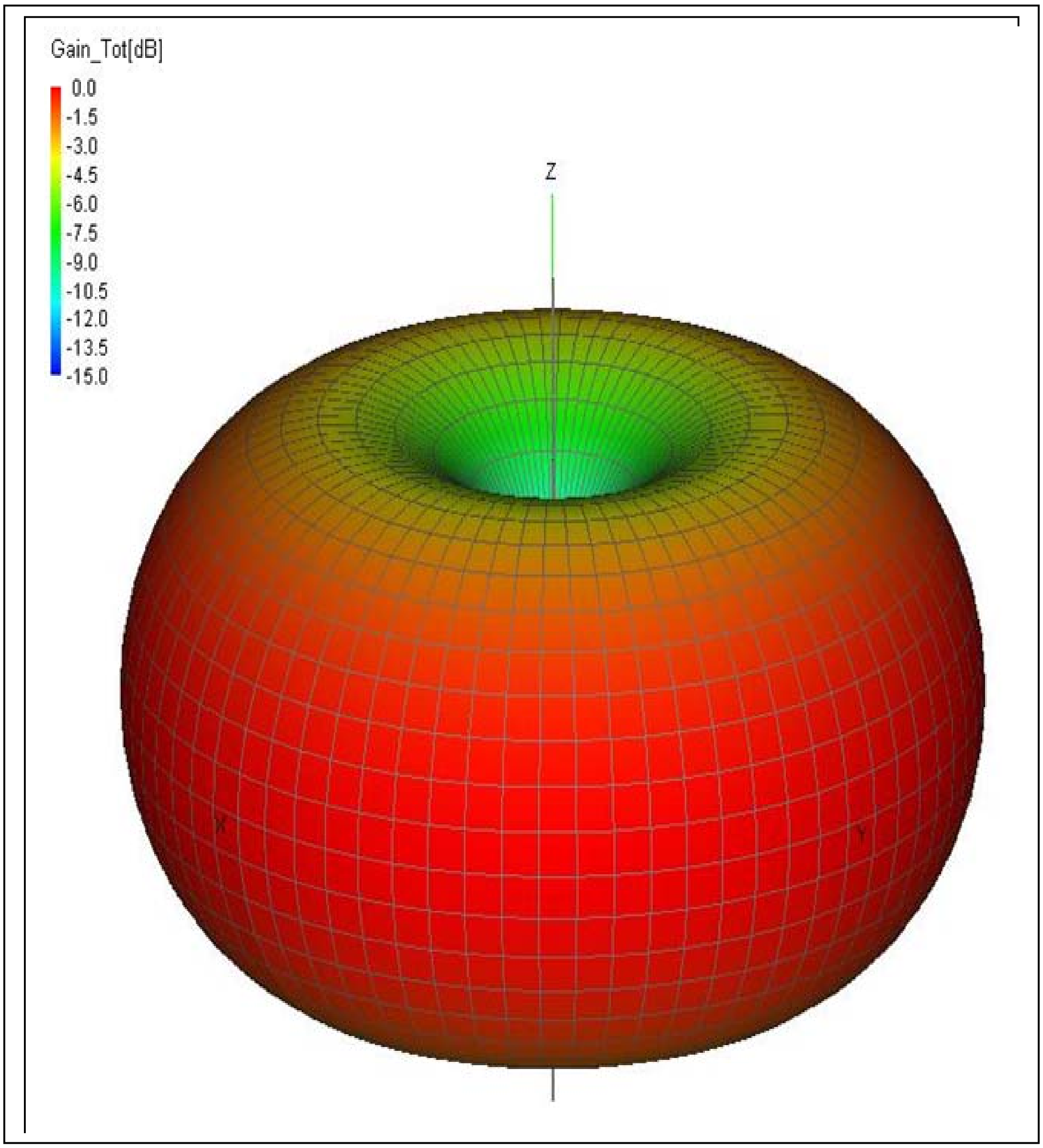


Fig 5.5 Three dimensional Radiation Pattern of Half wave Dipole

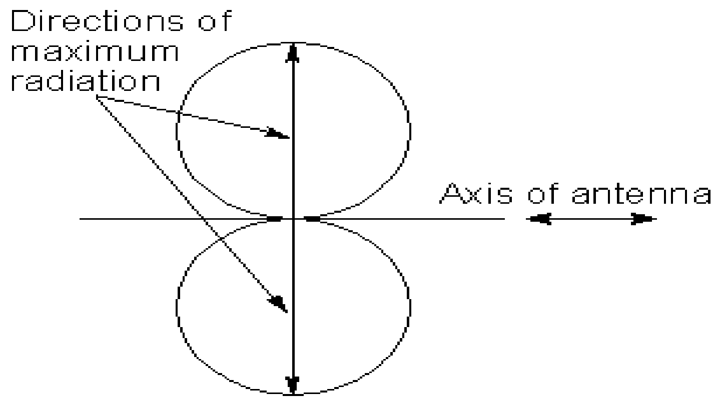


Fig. 5.6 Two dimensional cut radiation pattern of half wave dipole

The picture of 'Dipole antenna' is shown in fig 5.7. The dipole can be fixed either horizontally or vertically with respect to ground. In both the cases, the radiation pattern is the same. The maximum remains in the perpendicular direction to the antenna axis. But depending on whether antenna is placed horizontally or vertically the direction of the main beam will change. The dipole placed vertical with respect to the ground is shown in the diagram given below.

The angle 'θ' is measured from 'z' axis and the angle 'φ' is measured from 'x' axis.The variation of angle 'θ' by keeping another angle 'φ' at zero degree gives elevation pattern. Similarly by varying the angle 'φ' and keeping 'θ' at 90^o gives azimuthal pattern. These patterns are two dimensional patterns drawn based on actual three dimensional radiation pattern of the antenna.

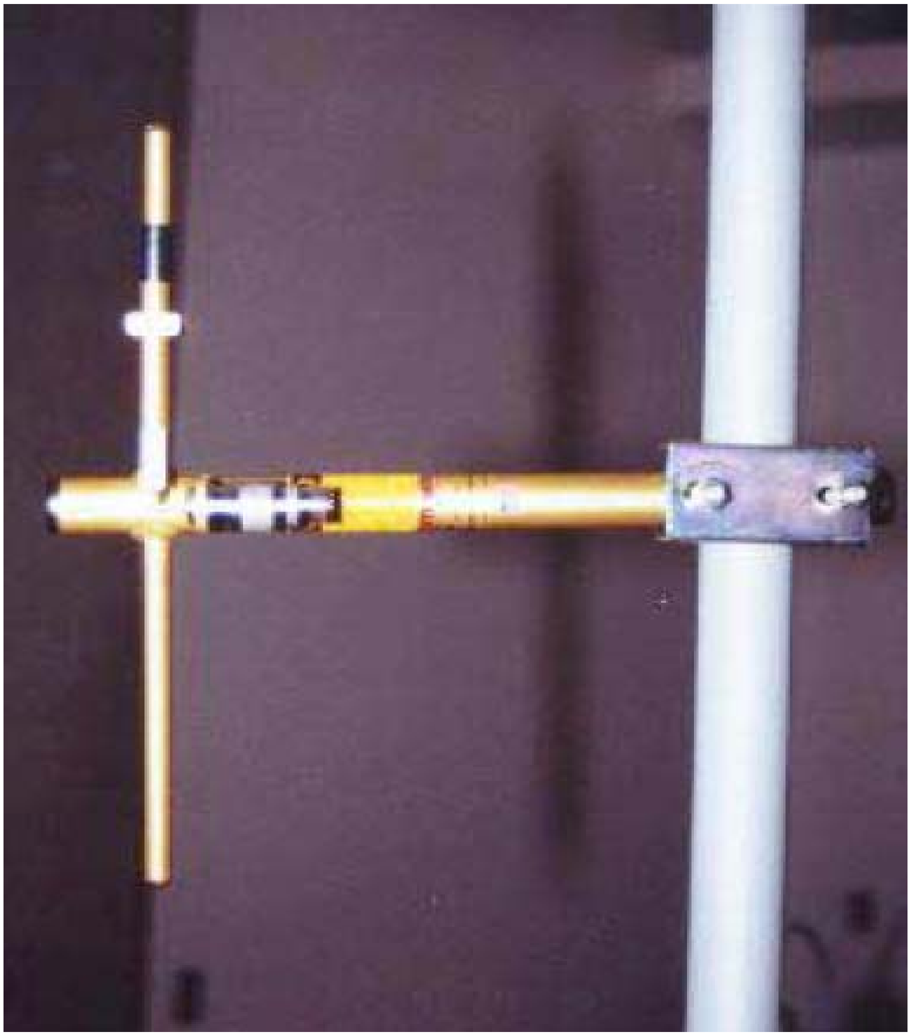


Fig. 5.7 Picture of dipole antenna

5.5.2 Aperture Antenna

'Aperture' means a small opening. The antenna is fed with such a small gap. The Horn antenna is considered as a perfect aperture antenna. Depending on the orientation of this antenna, it is known as 'E-Plane Horn', 'H-Plane Horn' and 'Pyramidal Horn'. Horn antennas have greater directivity and narrower bandwidth. Horn antenna is used as the test antenna in the calculation of gain in standard gain measurement method. The picture of a horn antenna is given in fig 5.8.

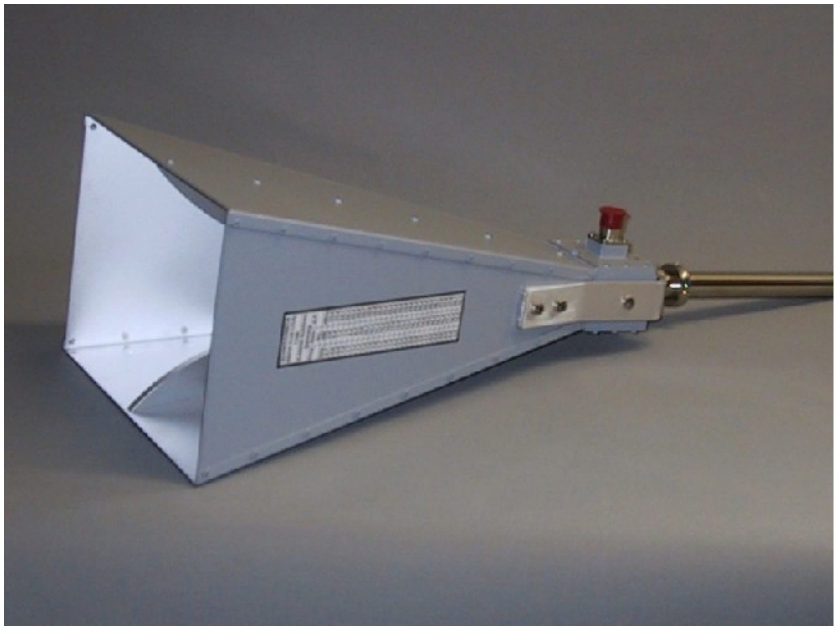


Fig 5.8 Horn Antenna

5.5.3 Reflector Antenna

The antennas which can have higher gain by reflecting EM waves on a surface are known as ‘Reflector Antenna’. Depending on the shape of surface, this antenna is classified such as parabolic reflector antenna. This antenna is used for satellite reception and has been used for satellite Television signal reception. ‘Direct to Home [DTH] Service’ is also utilizing this antenna. At the focal point of this antenna, a feed antenna is placed. Dipole or horn antenna is used as feeder for this antenna [17]. To increase efficiency of this antenna, feeder is placed at the back side of reflector. This is known as ‘Cassegrain feed’. Similarly the feeder is placed at one end is known as ‘Offset feed’. This antenna acts as excellent microwave reflector and concentrates signal in a particular direction. So, this antenna can provide better directivity. An image of parabolic reflector is given in fig 5.9.

Fig 5.9 Parabolic Reflector Antenna

5.5.4 Array Antenna – Yagi Antenna

The most easiest and efficient directional antenna is the 'Yagi – Uda' Antenna. It is named after its inventors Prof. Uda and Prof. Yagi. This antenna has been successfully used for VHF band terrestrial home Television reception.

The directivity is increased by increasing the number of directors which are known as 'Parasitic Elements' as they are not directly fed. Only the dipole or folded dipole is directly fed. There is one reflector which used to reflect EM signal. A sample yagi array is given in the following diagram.

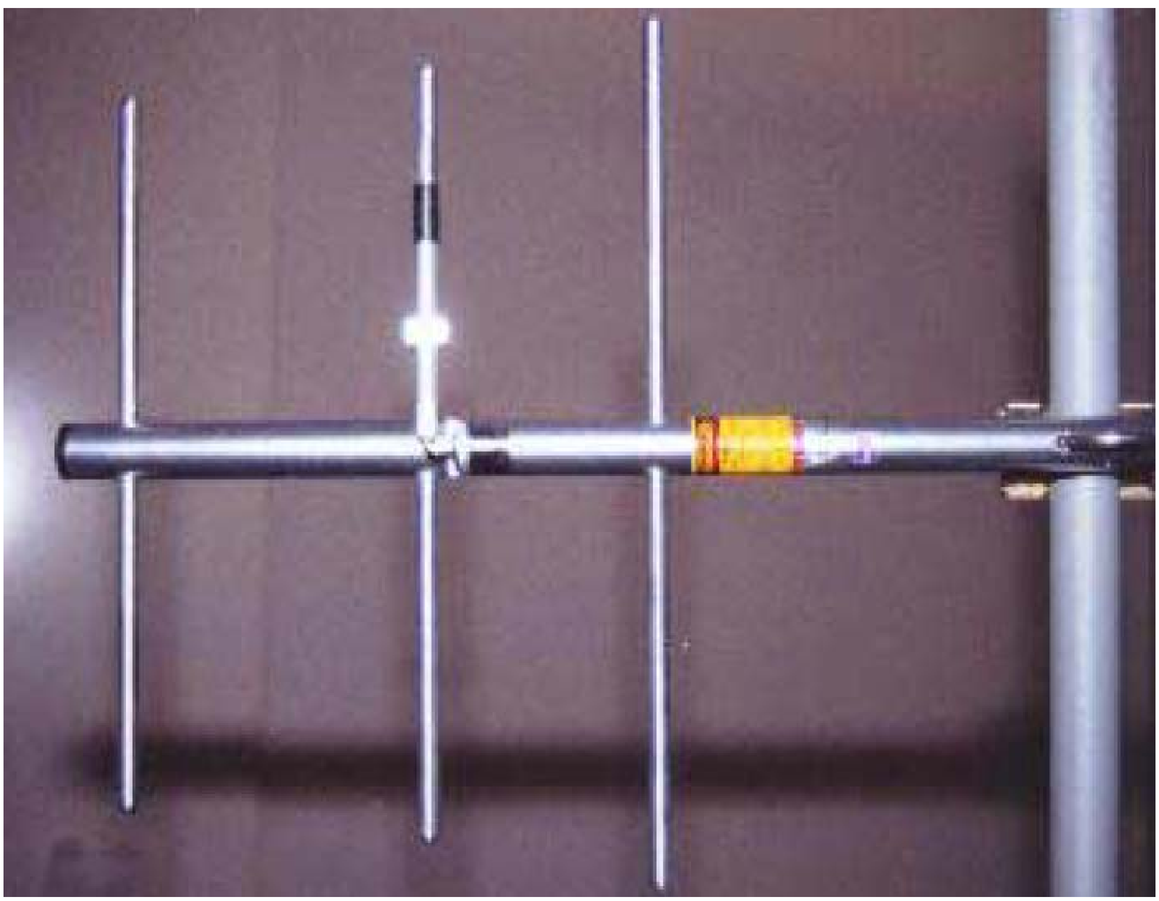


Fig 5.10 Three Element Yagi Array

The yagi array consists of at least three elements. The dipole or the folded dipole is at which the signal is fed. The length of the dipole is 0.5 λ with respect to the frequency of operation. The element on the left to the dipole in the above diagram is at 0.55 λ. The spacing between the dipole and the reflector is 0.3 λ. The element on the right of the dipole is known as 'Director'. It has the length of 0.45 λ. The spacing between the dipole and the director is 0.25 λ [17].

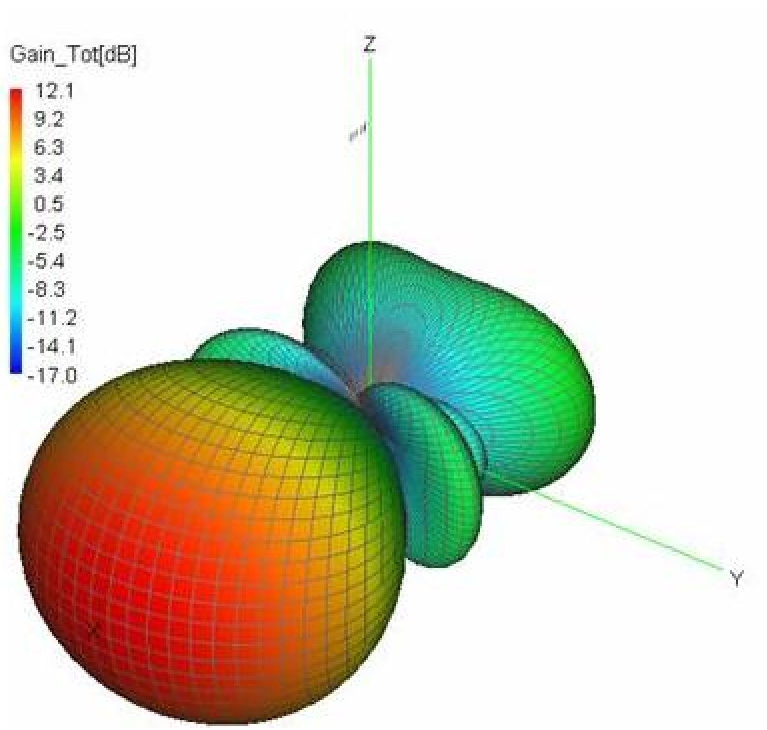


Fig 5.11 Three Dimensional Radiation Pattern of Yagi antenna

The above figure shows the radiation pattern of a yagi antenna. The major lobe of yagi antenna is at towards directors. EM signal is reflected by 'reflector' and it travels towards directors. There are also some side lobes and back lobes. These are radiating energy in unwanted direction. So, these lobes are to be reduced as much as possible so that the maximum of the energy is directed in the desired direction.

5.5.5 Micro strip patch antenna

The concept of ‘Microwave Integrated circuits’ was developed around 1970’s. But this field didn’t develop into an emerging field till the introduction of VLSI concepts. After late 1980’s, this field has lot of development. ‘Planar antennas’ are introduced based on this concept. Transmission lines were developed based on dielectric substrate materials. The width and length of the conducting lines are designed based on the operating frequency and the dielectric constant of the substrate material.

Micro strip antenna has few advantages such as low profile, easy to fabricate, easy to feed, easy to use as an array and hemispherical radiation pattern with moderate directivity of 6 to 8 dB. Micro strip antennas also possess some disadvantages such as low bandwidth and low efficiency. The diagram of a rectangular micro strip patch antenna is shown below.

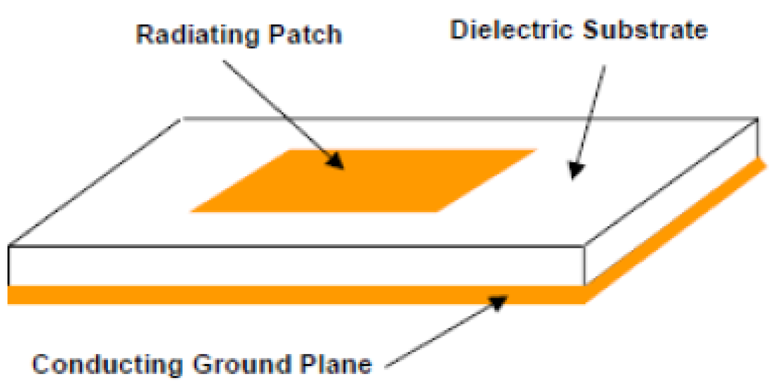


Fig 5.12 Micro strip antenna

A dielectric substrate with a known dielectric constant is selected as the base. On one side of this substrate, a thin conductor is placed through out the entire length. This is called as the ‘Ground Plane’. On the other side of the substrate, a conducting patch element is placed. The length and width of this patch are determined based on frequency of operation and relative permittivity of substrate. Though the patch is generally in rectangular shape, it may be of any shape. Coaxial feed, micro strip feed, aperture feed and proximity feed are few types of feeds used for micro strip antenna.

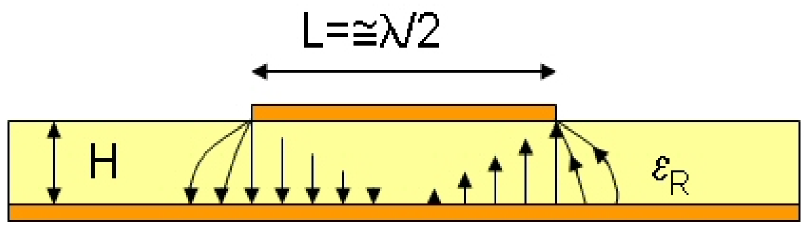


Fig. 5.13 Electric flux lines of micro strip

The electric flux lines start from the patch and travel towards the ground plane. In this process, some flux lines are traveling through the free space and the remaining through the dielectric material. So, an effective dielectric constant is to be calculated for any micro strip patch. The dominant mode of operation of micro strip is given as ‘Quasi TEM’ or Impure TEM. The magnetic flux lines form closed loops around the conducting patch [26].

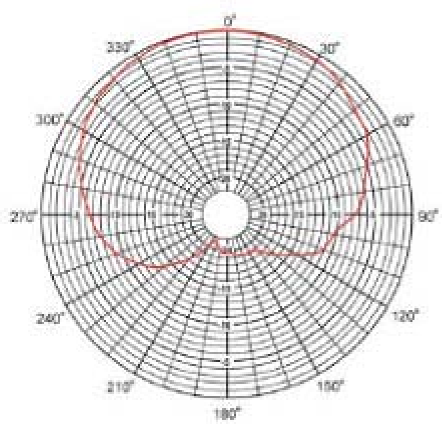


Fig 5.14 Radiation Pattern of Micro strip patch antenna

The radiation pattern of a micro strip antenna is unidirectional and its major beam is perpendicular to the plane of the antenna. As the other side of the dielectric material, ground plane is placed, antenna cannot radiate in that direction. The entire energy is directed in the perpendicular direction to the plane of the antenna. But this antenna can provide only narrow beam width radiation pattern. Generally, this antenna can operate with less amount of power.

Micro strip antenna is simple and easy to design and construct. It is having smaller shape and weight compared to other antennas which makes this antenna as an important one. This antenna can be compact and conformal. So, this antenna can be placed at any bends, rough walls and even at glass. With these advantages, almost the work on modern antennas narrowed down into the work on micro strip or its related antennas.

5.6 Conclusion

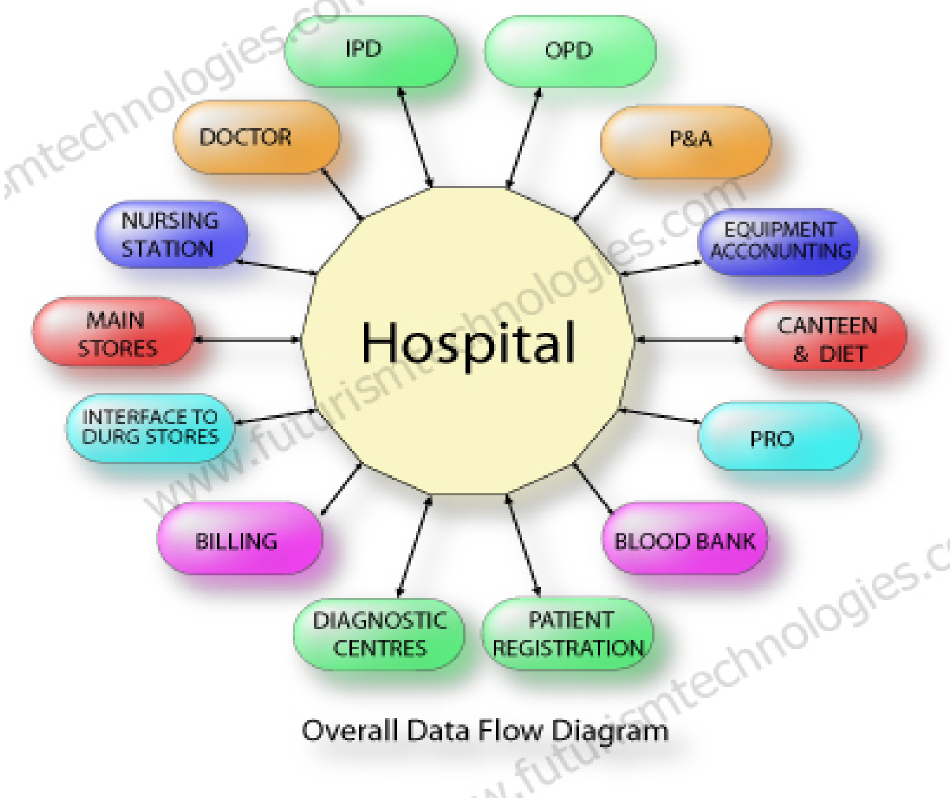
Antennas are generally classified into wire, aperture, reflector, array and patch antenna. In this chapter, basic antenna theory and various parameters of antenna are presented. The types of antennas and their radiation pattern are also discussed.

Directional antennas such as yagi array radiates EM wave in a particular direction. If any directional antenna is used as AP of WLAN, security can be improved. The design and fabrication of WLAN antenna which enhance security of WLAN is to be discussed in the next chapter.

Hospital Information System

HIS is a comprehensive, integrated information system built for managing the operations in running health care facilities (Hospitals). HIS as any other integrated system , needs time for developing , require special type of professional skills for development and software production but most importantly it costs money for development , installation , support and upgrade .

A general block diagram of HIS is shown in the figure:



ADVANTAGES

1. Hospital Information System helps in maintaining a totally secured database of Patients and business information. This information can be available at your fingertips.
2. Hospital Information System helps in improved healthcare delivery by providing medical personnel with better data access, faster data retrieval, higher quality data and more versatility in data display.
3. Hospital Information System helps in improving efficiency, both on the cost and the clinical care perspective. This is achieved by avoiding duplications, repetitions, delays, missing records and confusions.

4. Hospital Information System helps to force orderliness and standardization of the patient records and procedures in the clinic and increasing accuracy & completeness of medical records of Patient.

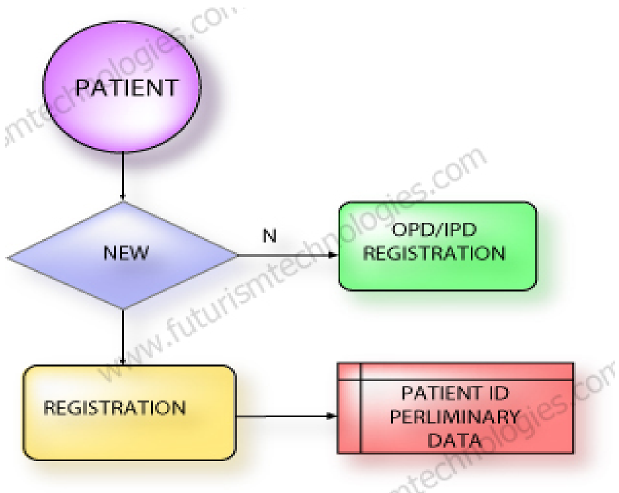
5. Hospital Information System helps as a good managerial tool to provide total, cost-effective access to complete and more accurate patient care data to offer improved performance and enhanced functions.

6. Hospital Information System helps in gathering information to meet management challenges.

7. Hospital Information System helps to educate patients about their diseases of surgical procedures through pictures and animations.

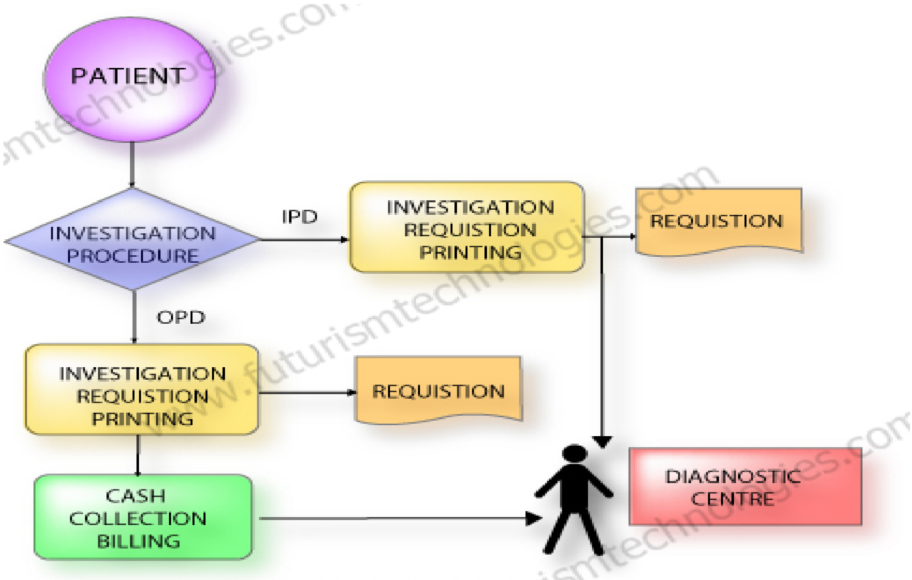
Structuring Medical Records to carry out functions like admissions ,discharge, treatment history etc:

Patient Registration: This function of Hospital Management Information System deals with registering the new Patient either for OPD or IPD and giving unique Identification Number to the Patient. This number is unique through out the System for identifying the patient. The patient can be registered either at IPD Front Office or at OPD Reception. The OPD or IPD identification number is also created for each separate visit of the patient. This is also a part of registering patient. IPD/OPD ID is used for tracking of medical records of the patient for that particular OPD visit or IPD admission. All the medical record of the patient are identified by combination of numbers i.e. Patient ID and OPD/IPD ID. The numbers gives flexible search in terms of finding patient's History Record.



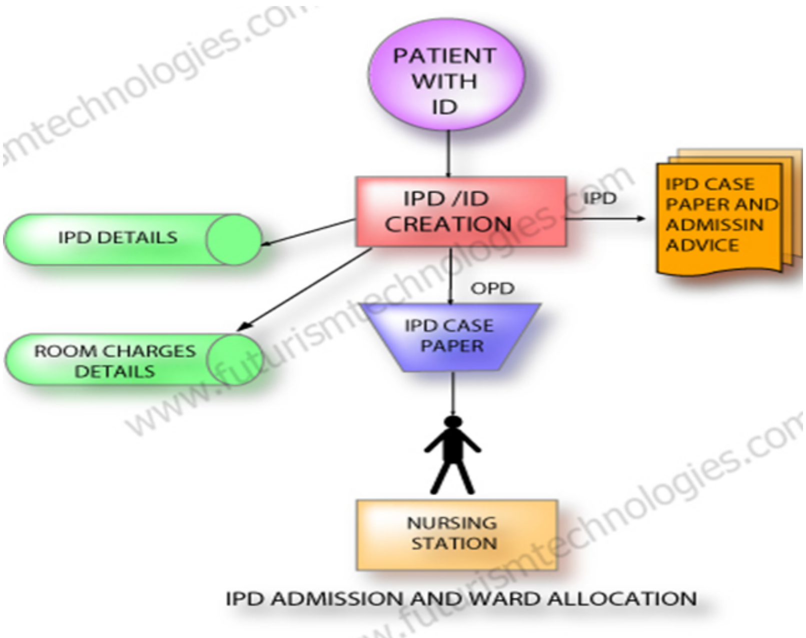
PATIENT REGISTRATION

OPD / IPD Investigation Cases: This Module of Hospital Management System deals with all kinds of Investigations suggested by Doctors. The function enables the entry of Investigations /Procedures for a particular patient. The entered investigations are rooted through the Billing/Cash office and once the patient pays for the Investigations the entries of the same goes to respective Diagnostics Center. This flow is not compulsory of IPD patients since the Billing for IPD patients is done at the time of Discharge. Investigation requisition is created and printed with function and the same is available at respective diagnostics center for preparation of Reports.



OPD / IPD INVESTIGATION CASES

IPD ADMISSION AND WARD ALLOCATION: This function Patient IPD Admission gives facility to process patient admission and allocate Bed to patient. System identifies the patient as new IPD patient or internal referred from hospital OPD/CMO. This function gives information on vacant beds in a Hospital. Occupancy status on that particular position can be find out while allocating the Bed. The main function Patient Admission facilitates admitting the patient according to requirement, considering the type of admission and the patient condition. The admission of the patient can be direct / Referred from a consultant / Hospital. The category of the patient can be Company, Self, Government Schemes, Insurance, and MLC depending on that the admission procedure is completed. Once the patient is admitted in the Hospital the Room charge starts from the time of Admission. The case paper of the patient is printed from the system and is send to the respective Nursing Station. Once the Admission of the patient is completed the IPD Identification Number is created by the system for that particular Admission of Patient. The IPD Admit Card is also printed along with the Case Paper. The system informs with Audio Visual alert to the respective Nursing Station about admission of the patient under them and to prepare Room for patient. In case of MLC, system stores the details of the Police Station, Name of the official informed about Medical Legal Case.



PATIENT SHIFTING: This function of Hospital Management System facilitates to Shift patient from one Room to other inside the Hospital. With this facility patient's actual position can be updated on line so that the internal functions such as Billing, Investigations, Surgery are planned. The position of the patient is very important since all the charges like Surgery. Procedures, Investigations are related to Room Category.

DEPOSITS, ADVANCES, REFUNDS, DISCOUNTS AND CONCESSIONS:

This function of Hospital Management System facilitates all kind of financial transactions from the patient. Function plays vital role in payment recovery from patients time to time during the stay. The Advances from the patient depends on the Type of Admission and the Patient category is prompted by the System. The Interim Bill vs. Advances ratio is also maintained to carry out recovery planning. Advances and the deposits accepted by the Billing/Cash counter are directly posted into Accounts. Refund cases are considered for excess Advances from the Patient. The Accounts Official authorizes this transaction and then refund is processed. In case of Company category patient the ration analysis between Interim Bill and the Authority letter amount by the company is compared for further action. If patient is to be given Discounts then the authorized person authorizes the Amount and the discount is processed. The discount categories are flexible and can be changed by the administrator. This facilitates easy way to keep track on the discounts and concession.

Following are the main reports / outputs generated by HIS:

- **Patient List – Admitted / Discharged.**
  This report gives information on admitted/discharged patients during certain time period. This facilitates management to know the Admission vs. Discharges ratio.
- **Bed occupancy Reports.**
  This report gives information on Bed Occupancy at any given time room category wise.
- **Ward Allocation Reports.**
  This report gives allocated rooms report for tracking of patient.
- **Interim Bill v/s Advance Report.**
  This report gives the ration of Interim Bill vs. Advances paid by the patient with the percentage of payment.
- **Admission / Discharge Register.**
  Admission and Discharge register is maintained by the system. This report gives details of patient Admission and discharges during specific period.
- **Consultant wise patients**
  This report gives Doctor wise patients at any point of time to know referring or In-charge doctor.
- **Appointment List**
  The appointments for consultants are maintained on the system.
- Performed operation list.
- Patient follow-up report.
- DIAGNOSTIC CENTRES
- This module enables to get patient's investigation, procedure record from different locations i.e. IPD, OPD, Casualty.

Automated Clinical Laboratory Systems & Radiology Information System:

This function of HIS covers Laboratory System for Pathology, Radiology, Cardiology, Neurology, and Chest Medicine. The prescriptions given by the Doctors are routed through billing system to respective Diagnostic Centers.

Pathology

Laboratory module starts with receiving the online request from doctors. Laboratory personnel can also generate requests. This facilitates investigations for referral patients. Tests are grouped under various sections and sample type (specimen). Based on the request the user can input the sample and generate the sample number. Results can be inputted based on the sample type. Results can be inputted either to one test or multiple tests. If the test result requires approval, the supervisor has to approve the result. Test results are available to concerned doctors. Test report can be made confidential. Tests can be performed only after the billing is done. This rule is exempted when the case is declared as Urgent.

- Integration of tests Ordered from Clinical Modules
- Comprehensive On-line Laboratory Reports

- Fast Entry of Results
- Enables Doctors to see the Results On-Line from any Location at any time
- Up-to-date status about request
- Provision for templates of Input of test Results

Radiology

Radiology module caters to services such as X-ray, Scanning, Ultra sound etc. Scheduling of Radiology resources is possible. The system stores all the result details of various tests and makes a Report based on the Test Results. These Tests are carried out both for Inpatient and Outpatient. The system stores all the details (like patient number, Test Report like X-Ray, Scanning details) and for each scan the system generates a unique number for the image.

Investigations can be done only after the billing is done. This rule is exempted when the case is declared as Urgent.

- CT Scanning: Direct Capturing of CT Scanned images, Easy Reporting facility
- MRI: Easy reporting
- X-Rays: Direct Capturing of X-Ray images

Sonology

- Sonography Reporting
- Capturing of Images

Cardiology

- ECG Notes

Neurology

- EMG Reporting
- Prescriptions Discharge Card

Blood Bank

This module is developed keeping in view the legal and other requirements of operating the Blood Banks. It deals in detail with blood transfusion centers and the component laboratories and works as is online interactive system. It also generates legal as well as internal operation records.

Functions

- Donors data entry, Details of Donors such as Name, Address, Contact Numbers, Blood group are maintained in the system through Donors data entry.
- The details can be printed as and when required. The mailing list from the available data of donors can be printed for Correspondence.
- Investigation Data Entry
- Various tests details are stored in the system for as per rules of Blood Bank.
- Maintains data of tests
- Tests data details required for Blood Bank records are stored into the system with specific results on HIV, HB details.
- Facilitates component level administration of the blood units
- Keeps track of distribution / disposal of the whole blood and the components
- Signals expiry dates and components characteristics

Reports

- Blood Stock Register
- Donor register as per FDA requirements
- Investigation Report
- Blood Issue Register
- Demographic data of Donors

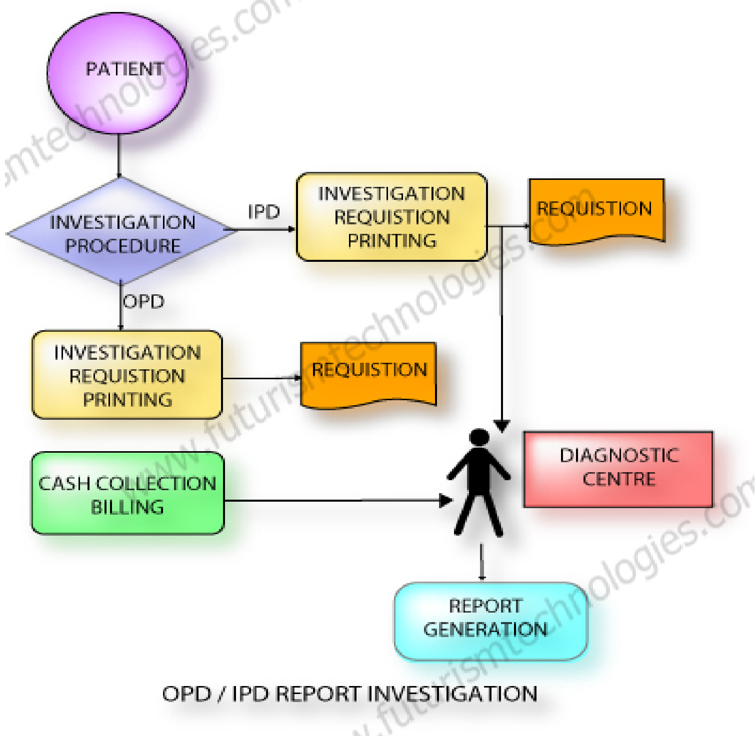


Figure: Radiology Information System

Role of Database in HIS

Database is the heart of Hospital Information system. It consists of an orderly written document encompassing the patient's identification, health history, physical examination findings, laboratory reports, treatment, surgical procedure reports and hospital course. When complete, the record should contain the data to justify investigations, diagnosis, treatment, and length of stay, results of care and future course of action". Thus, it becomes a tool :

- To provide a means of communication among physicians, nurses and other allied health care professionals
- To provide Continuity of patient care, help in medical education and research
- To provide information for the quality review of patient care
- To protect legally the physician, patient, hospital and helps in third party payment.
- Failure to maintain an accurate, timely and complete database spoils the usefulness of HIS.

Medical Records are valuable to patients, physicians, nurses, teachers, students, and health care institutions, and research teams, national and international organizations.

* Advantages of having good database can be taken from Advantages of HIS.

Need of Networking in HIS

Networking plays an important role in Hospital Information System, with new applications that improve patient care and drive down spiraling healthcare costs. However, rapid changes in next generation wired and wireless healthcare applications mean that the network is no longer an option, but a necessity. HIS providers are under increasing pressure to provide an infrastructure that can be optimized for these next-generation applications. Applications such as electronic Medical records (EMR) and wireless monitoring and the increasing use of handheld devices and broader imaging distribution all drive the need for network upgrades to provide a more robust, higher-performing, and secure network infrastructure. This infrastructure is critical to reduce staff wait times and allow staff and patient mobility, equipment tracking, and broader integration of data systems. even with the need to control costs, HIS providers are still expected to fund network growth as more and more devices are connected via the wired and wireless network. Although higher performance and lower total Cost of ownership (TCO) may be conflicting goals, Hospitals find HIS exceed performance and cost expectations, but can do so while providing a more secure and flexible network infrastructure that can scale to meet growing connectivity demands.
Depending on the size and function of the institution, hospital network architectures can vary significantly in complexity and scope. Although the basic architecture for a hospital network is similar to the architecture of other campus networks, responding to the dynamic changes in improved patient care and cost control requires significantly more planning and strategy than was previously required. HIS networks demand greater flexibility in supporting a wide range of medical devices and applications including EMR, PACS, collaboration, handheld devices, wireless patient monitoring, and

other services. As more and more wired and wireless services are used and the network must support patient care, an efficient network is no longer a luxury, it is a necessity.

HEALTH EDUCATION

Health education is the profession of educating people about health. Areas within this profession encompass environmental health, physical health, social health, emotional health, intellectual health, and spiritual health. It can be defined as the principle by which individuals and groups of people learn to behave in a manner conducive to the promotion, maintenance, or restoration of health. However, as there are multiple definitions of health, there are also multiple definitions of health education. The WHO defined Health Education as "comprising consciously constructed opportunities for learning involving some form of communication designed to improve health literacy, including improving knowledge, and developing life skills which are conducive to individual and community health."

Need of Health Education: Education for health begins with people. It hopes to motivate them with whatever interests they may have in improving their living conditions. Its aim is to develop in them a sense of responsibility for health conditions for themselves as individuals, as members of families, and as communities. In communicable disease control, health education commonly includes an appraisal of what is known by a population about a disease, an assessment of habits and attitudes of the people as they relate to spread and frequency of the disease, and the presentation of specific means to remedy observed deficiencies.

Health education is also an effective tool that helps improve health in developing nations. It not only teaches prevention and basic health knowledge but also conditions ideas that re-shape everyday habits of people with unhealthy lifestyles in developing countries. This type of conditioning not only affects the immediate recipients of such education but also future generations will benefit from an improved and properly cultivated ideas about health that will eventually be ingrained with widely spread health education. Moreover, besides physical health prevention, health education can also provide more aid and help people deal healthier with situations of extreme stress, anxiety, depression or other emotional disturbances to lessen the impact of these sorts of mental and emotional constituents, which can consequently lead to detrimental physical effects.

Role of Health Education in Society: Health education is the continuous process of enlightening people about the ways of achieving and maintaining good health. It focuses on informing them so as to motivate their actions towards the initiation of a change in their lifestyle that is in the greater interest of the environment.

Products and services from a wide range of organizations and invidious are brought under the cover of a typical health care education industry. An organization or an individual who is engaged in the field of providing products or services that contribute towards the improvement or maintenance of health are considered as providers of education and health care.

However, even if the present day society is well aware of health issues, the importance of exercise and nutrition, still most individuals cannot stop themselves from smoking, eating junk food leading to development of flab in the body and spend most of their lives in a lethargic manner. The account goes well for most of the adolescents and adults.

Health education has a crucial role to play in schools. The maintenance and promotion of health education in schools has been aptly considered vital by those engaged in health education services. The reason for giving preference to schools is that student age is the only time that individuals are able to reach a level of energy and strength that they ever reach during their lives. Additionally, they also tend to have a sense of invulnerability and uniqueness that makes them think that disorder and illness will not affect their lives. And, most of the adolescents have a conception that they are going to be here forever and that they can always recover from any bad habits or health losses that may come in their lives. Even with the best of physical features, most adolescents lead a life of unhealthy habits. This is where health education plays an important role in schools.

HEALTH INSURANCE

Health insurance is insurance against the risk of incurring medical expenses among individuals. By estimating the overall risk of health care expenses among a targeted group, an insurer can develop a routine finance structure, such as a monthly premium or payroll tax, to ensure that money is available to pay for the health care benefits specified in the insurance agreement. The benefit is administered by a central organization such as a government agency, private business, or not-for-profit entity.

Importance: An English proverb says that “Health is Wealth”. It is not a meaningless saying as it defines a very important fact of life. Your health is the most precious wealth that God has given you. It is your own property and you are the sole owner of it. Therefore, it is your responsibility to look after it properly. However, it is also true that the life is full of uncertainties and you never know what will happen in the next few hours. Therefore, it is also your duty to make certain arrangement so that you can take care of yourself as well as your family even if some misfortune falls upon you.

Here comes the importance of health insurance program. This health insurance program, as the name itself tells, is entirely meant for the proper care of your body and health. It is a permanent arrangement that you can avail at a time when you need to undergo some serious health disorder. These health disorders are very expensive by nature and you may need the help from some sources to meet the expenses of this treatment. As you all know, the cost of medical treatment has become very costly and a person from the lower or middle income group cannot think about such a costly treatment.

A health insurance program is a service of the insurance companies that keeps your ensured against any serious illness like cancer. If, unfortunately, you happen to suffer from this serious disease ever in your life, you would not be worried about the cost of treatment as you can get the sum for treatment. As far as success of treatment is concerned, it is not sure, however, your family gets a huge sum of money if you happen to die in the process of your treatment.

The advantage of this health insurance program is very unique. You need not spend a penny from your pocket and the whole cost of treatment is borne by the insurance company. It is a great relief for the members of your family as well because they need not worry about your treatment. A health insurance program is a very useful investment because it helps you at the time when you need the money most. If you do not have the health insurance program for yourself, then you will be in deep trouble when a situation like occurs in front of you and leaves you in want of a huge sum of money.

Reasons for poor penetration of health insurance: Penetration of health insurance has been slow and halting, despite the 'huge market' estimated to range between Rs 7.5–20 crores. Some reasons that explain for the slow expansion of health insurance in the country are as follows:

- Lack of regulations and control on provider behavior: The unregulated environment and a near total absence of any form of control over providers regarding quality, cost or data-sharing, makes it difficult for proper underwriting and actuarial premium setting. This puts the entire risk on the insurer as there could be the problems of moral hazard and induced demand. Most insurance companies are therefore wary about selling health insurance as they do not have the data, the expertise and the power to regulate the providers. Weak monitoring systems for checking fraud or manipulation by clients and providers, add to the problem.

- Unaffordable premiums and high claim ratios: Increased use of services and high claim ratios only result in higher premiums. The insurance agencies in the face of poor information also tend to overestimate the risk and fix high premiums. Besides, the administrative costs are also high—over 30%, i.e. 15% commission to agent; 5.5% administrative fee to TPA; own administrative cost 20%, etc. Patients also experience problems in getting their reimbursements including long delays to partial reimbursements.

- Reluctance of the health insurance companies to promote their products and lack of innovation: Apart from high claim ratios, the non-exclusivity of health insurance as a product is another reason. In India, an insurance company cannot sell non-life as well as life insurance products. Since insurance against fire or natural disaster or theft is far more profitable, insurance companies tend to compete by adding low incentive such as premium health insurance products to important clients, cross-subsidizing the resultant losses. With a view to get the non-life accounts, insurance companies tend to provide health insurance cover at unviable premiums. Thus, there is total lack of any effort to promote health insurance through campaigns regarding the benefits of health insurance and lack of innovation to make the policies suitable to the needs of the people.

- Too many exclusions and administrative procedures : Apart from delays in settlement of claims, non transparent procedures make it difficult for the insured to know about their entitlements, because of which the insurer is able to, on one stratagem or the other, reduce the claim amount, thus demotivating the insured and deepening mistrust. The benefit package also needs to be modified to suit the needs of the insured. Exclusions go against the logic of covering health risks, though; there can be a system where the existing conditions can be excluded for a time period—one or two years but not forever. Besides, the systems entail equity implications.

- Inadequate supply of services: There is an acute shortage of supply of services in rural areas. Not only is there non-availability of hospitals for simple surgeries, but several parts of the country have barely one or two hospitals with specialist services. Many centres have no cardiologists or orthopaedicians for several non-communicable diseases that are expensive to treat and can be catastrophic. If we take the number of beds as a proxy for availability of institutional care, the variance is high with Kerala having 26 beds per 1000 population compared with 2.5 in Madhya Pradesh.

HEALTH LEGISLATION

Health legislation encompasses the laws, ordinances, directives, regulations and other similar legislative instruments that deal with all aspects of health protection and promotion, disease prevention, and delivery of health care.

Health Legislation in India: A Compilation

Health is a State subject and, in many areas, the state government legislations are applicable. Given the enormity of the task of compiling all health related laws, this compilation is restricted to laws applicable at the central level and those related to health and health care issues. Over 200 Acts and Rules in this compilation were collected over a period of time from different sources, too many to be mentioned. Key health related international covenants and guidelines have also been included.

The categorization of legislations has been adapted from the WHO classification. The broad areas covered include:

- Health Facilities and Services
- Disease Control and Medical Care
- Human Resources
- Ethics and Patient Rights

- Pharmaceuticals and Medical Devices
- Radiation Protection
- Hazardous Substances
- Occupational Health and Accident Prevention
- Elderly, Disabled, Rehabilitation and Mental Health
- Family, Women and Children
- Smoking, Alcoholism and Drug Abuse
- Social Security and Health Insurance
- Environmental Protection
- Nutrition and Food Safety
- Health Information and Statistics
- Intellectual Property Rights
- Custody, Civil and Human Rights
- Others

HEALTH FINANCING SYSTEM

Financing is the most critical of all determinants of a health system. The nature of financing defines the structure, the behaviour of different stakeholders and quality of outcomes. It is closely and indivisibly linked to the provisioning of services and helps define the outer boundaries of the system's capability to achieve its stated goals.

Health financing is by a number of sources: (i) the tax-based public sector that comprises local, State and Central Governments, in addition to numerous autonomous public sector bodies; (ii) the private sector including the not-for-profit sector, organizing and financing, directly or through insurance, the health care of their employees and target populations; (iii) households through out-of-pocket expenditures, including user fees paid in public facilities; (iv) other insurance-social and community-based; and (v) external financing (through grants and loans).

While taxation is considered the most equitable system of financing, as tax is a means of mobilizing resources from the richer sections to finance the health needs of the poor, out-of-pocket expenditures by households is considered the most inequitable. Under a system dominated by out-of-pocket expenditures, the poor, who have the greater probability of falling ill due to poor nutrition, unhealthy living conditions, etc. pay disproportionately more on health than the rich and access to health care is dependent on ability to pay.

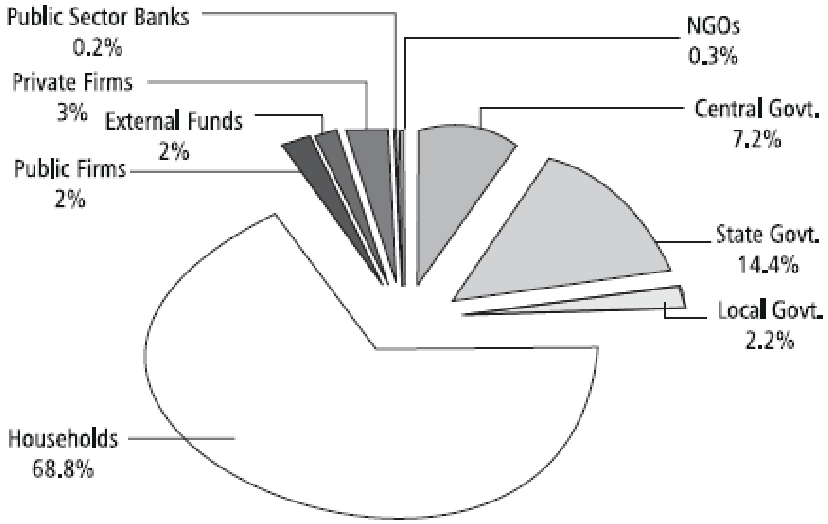
Assessing how pro-poor a system of financing is again depends on how the different types of financing interact with each other. For example, a country may have a social health insurance policy but may not cover public hospitals as they are in theory expected to provide free care. In such a situation there may be greater incentives for patients to go to private hospitals as expenses are covered by insurance resulting in no incentives for the public hospitals to function well. In that case, the poor who have no immediate access to insurance or private hospitals may stand to lose with poor quality public care.

In India, as in most countries, there is a clear urban-rural, rich-poor divide. Affluent sections, urban populations and those working in the organized sector covered under some form of social security such as the ESIS or CGHS, have unlimited access to medical services. The rural population and those working in the unorganized sector have only the tax-based public facilities to depend on for free or subsidized care, and private facilities depending on their ability to pay. The impact on equity then gets determined on whether the tax-based public facilities are able to provide a similar quality of care as provided under the Social Health Insurance Scheme. Because, if funding is low and the quality of care falls below expectation, is inaccessible, entails informal payments, etc. then the benefit of free care at the public facility gets neutralized with the second option of paying out-of-pocket to a relatively hasslefree private provider available close by, making the system of financing inequitable as well as inefficient. How and why this is so will be discussed in this section, as an understanding of the current structure of financing is important to identify future options for a better system.

Health Spending in India

Health spending in India is estimated to be in the range of 4.5%-6%. These estimates are based on a weak methodological background. Therefore, an exercise was undertaken to construct estimates of health spending based on a National Health Account (NHA) framework. Such an approach enables a better and more reliable understanding of the size and structure of health financing in India. Results from the NHA show that the estimated health expenditure in India for the year 2001-02 was approximately Rs 108,732 crore, accounting for 4.8% of the GDP at current market price, while health expenditure as a percentage of the GDP measured at factor cost works out to 5.2%. Out of this, Central, State and local Governments together spend one-fourth of the total health expenditure. The share of other central ministries, which include railways, defence, posts and telegraphs, other civil ministries, etc. is estimated to be about 2.42% of total health spending in the country. The estimate is based on direct spending by the ministries as well as reimbursements provided to its employees. Local governments' resources for health are through transfers from State Governments and their own resources. An estimated 2.2 % of total health spending comes from the local government. The estimate involves only spending by municipalities and not Panchayati Raj institutions. It is to be noted that municipalities (in metros and particularly Mumbai Municipal Corporation) are major contributors among local governments while the share of Panchayati Raj institutions are a miniscule part of the health budget, since a substantial part of the panchayat's are mostly composed of either Central or State transfers.

Sources of finance in the health sector in India during 2001-02



Regarding private spending on health, the NHA matrix reveals that 71% of the health budget is contributed by private sector, of which households alone spend 69%. As a percentage of the GDP at current market prices, households spend an estimated 3.3%. Spending by private firms is in various ways: either through their own health facilities, or by providing a lump sum amount to the employee for health, or reimbursing a part of the health expenditure incurred or by contributions to insurance schemes such as ESIS or voluntary private insurance schemes. External aid to the health sector, either to the Government or NGOs, taken together forms 2% of the total health budget.

A report from WHO says Health sector in India suffers from gross inadequacy of public finance and therefore an immediate and significant scaling-up of resources is an imperative. Further, there is an urgent need to restructure the budgeting system to make it more functional, amenable to review of resource use to take corrective measures in time and be flexible enough to have the capacity to respond to an emergency or local need. Rules and procedures for actual release of funds, appointment of persons, labour laws, procurement systems all need a thorough review. Greater decentralization of funds, aligned with functional needs and responsibilities, is necessary. However, any decentralization and financial delegation needs to be carefully calibrated and sequenced. In other words, decentralization can only be done after developing the requisite financial capability and laying down rules and procedures for accounting systems. Unless such restructuring takes place, greater absorption of funds will continue be difficult.

Health Financing

Access to quality healthcare in the private sector till now is limited by the high cost for the vast majority of India's population. However, this is changing dramatically with the advent of health financing as a preferred tool to cover for most healthcare expenditures.

Health financing essentially involves arranging for payment of a health service that has been arranged for under the financing contract.

Health insurance forms a major part of financing. It is growing exponentially with large and diverse players having entered the fray and enticing consumers with an ever-growing array of schemes. This is proved by the fact that healthcare insurance premium collected in 2005-06 registered a growth of 35% over year 2004-05.

The entry of pure Health Insurance companies into the marketplace in 2007 promises a plethora of innovative products. Swiss Re estimates a potential of US$ 7,700 million in health insurance premium by 2015.

Foreign Direct Investment (FDI) limit in health insurance has rose from 26% to 49%, which would result in surge of international players & even more customized offerings targeting all sections of society. In the event of the minimum capital requirement of US$ 25 million being reduced to US$ 12 million, a number of stand-alone players like Atar Health, Apollo DKV have come into being, as is the trend across the world for health insurance.

Less than 10% of India's population today has some or the other form of health insurance covers: either voluntary or as a part of the Employees State Insurance, Central Government Health Scheme or Community Insurance.

<u>The existing models of health financing are:</u>

Government Funded

In theory, this system is a universal pooling arrangement that involves the entire population. It provides access to publicly provided services financed through general revenues. In practice, it usually coexists with one or more of the other risk pooling arrangements.

State-funded systems are suitable for most countries having the capacity to raise taxes, establish an efficient network of providers, and need to target the poor.

It is a simple mode of governance and a potential for administrative efficiency and cost control.

It provides:

- A comprehensive coverage to the population, and
- A large scope for raising resources

Government supported

Social health insurance

- Social health insurance system is established in approximately 60 countries.
- It can be easily differentiated from general systems by independent or quasi independent insurance funds, a compulsory earmarked payroll contribution, and a clear link between the contributions and defined rights for the insured population.
- The main features of social health insurance are
- Financing mainly through employee and employer payroll contributions.
- The efficient management by nonprofit insurance funds.
- The existence of a benefits package.
- This provides
- More resources for the health care system.
- Less dependence on budget negotiations than state-funded systems.
- High redistributive dimension.; and
- A strong support by the population.

Community based health insurance

Community-based health insurance schemes are also referred to as health insurance for the informal sector, mutual health organizations, or micro-insurance schemes. This was the basis for the creation of social health insurance systems in countries such as Germany, Japan, and Korea and the overall health financing strategy in a number of countries.

Today in low-income countries, community-based health insurance plays an increasing role in providing medical coverage to populations without access to other forms of formal medical protection. These schemes are also slowly penetrating the rural market.

It provides better access to health care for low-income people and has also been proved as useful as a component of a health financing system involving other instruments.

Micro financing

Microfinance is the provision of financial services to low-income clients or solidarity lending groups including consumers and the self-employed, who traditionally lack access to banking and related services.

More broadly, it is a movement whose object is "a world in which as many poor and near-poor households as possible have permanent access to an appropriate range of high quality financial services, including not just credit but also savings, insurance, and fund transfers." Those who promote microfinance generally believe that such access will help poor people out of poverty.

Microfinance is a broad category of services, which includes microcredit. Microcredit is provision of credit services to poor clients.

Private

Voluntary health insurance

"Voluntary" or "Private" health insurance is a health financing model that is predominantly prevalent in high-income countries as a complement to the publicly financed systems.

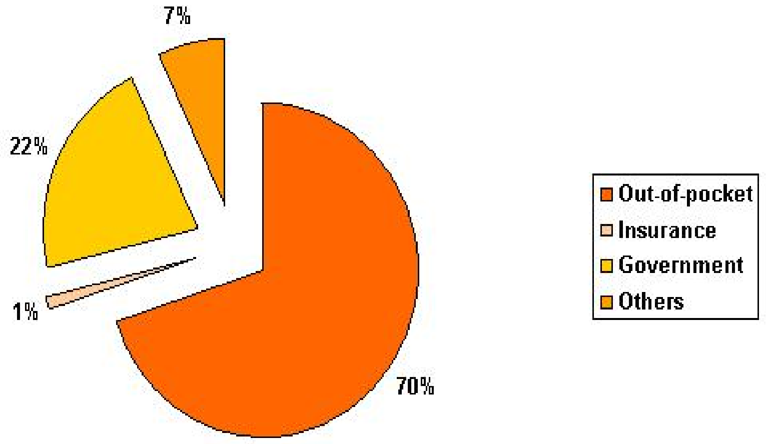
In practice, voluntary or private health insurance arrangements cover a wide spectrum of voluntary financing mechanisms and share diverse relationships with public and private health sector inputs.

It provides:

- An affordable financial protection (compared with out-of-pocket expenditure)
- An enhanced access to health services
- For an increased service capacity and promotes innovation, and
- Towards financing health care services not covered publicly, as in the case of supplementary private health insurance.

Healthcare systems can function effectively and efficiently under the ambit of structured & organized financing mechanism. In terms of expenditure on health, the private and public investment is roughly in the ratio of 80:20 respectively. With regards to healthcare and services spending, 62 per cent is self-sponsored. The Government contributes 24 per cent, employer provides for 9 per cent and only 5 per cent comes through insurance. This is dismal, when we discover that only Rs 250 crore is being collected for health insurance, whereas life insurance gets Rs 25,000 crores and even non-life items get Rs 9,000 crores towards insurance.

Private financing is gaining momentum, with about 70 % of the healthcare expenditure is out-of-pocket, which is increasing much more higher than the per capita income growth.



Due to advancement in technology, improvement in infrastructure and emphasis on quality etc, the cost of healthcare services is escalating. This is affecting the Indian middle and lower class directly. With passage of time alternative health financing mechanisms like Healthcare Insurance come into being to streamline & address the issue of inequitable and unaffordable healthcare delivery.

Benefits of Health Insurance:

- Protection against catastrophic financial burden in case of unexpected illness or injury

Pooling of resources Limitations:

- Hospitals tend to overcharge
- Absence of regulatory framework for providers
- Difficulty in handling fraudulent claims for insurance companies

Third Party Administrators or TPAs came into being to address these limitations. They are intermediaries that coordinate between Insurance companies and hospitals. From here emerged the concept of cashless hospitalization. While the insured is benefited by better service, insurers are benefited by reduction in their administrative costs, by outsourcing their management administrative activities, including settlement of claims at a certain cost. They come under the purview of Insurance Regulatory and Development Authority (IRDA), India. There are at present 27 TPAs registered under IRDA (as on 31st August 2007).

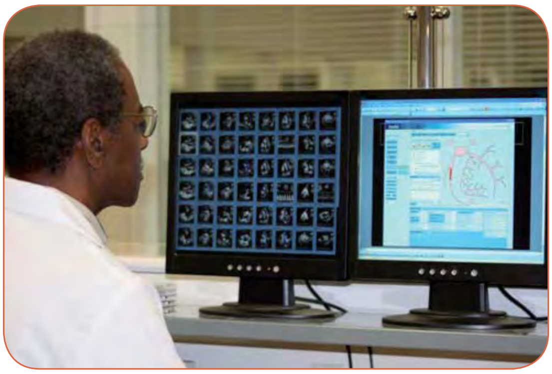
Videoconferencing system, Telemedicine

UMDNS		GMDN	
18138	Information Systems, Telemedicine, Videoconferencing	36303	Video conferencing telemedicine system

Other common names:
Teleconferencing Systems, Video; Teleconsultation Systems; Telemedicine Videoconferencing Systems; Video Teleconferencing Systems; Videoconferencing Systems, Telemedicine

Health problem addressed

These systems are used for diagnosis and prescription of medical treatment for patients at remote locations, for remote clinical consultations between medical professionals, for education and training of medical staff, and for administrative/business functions. Telemedicine can be as simple as a telephone conversation between personnel or a fax transmission, or as complex as a real-time interactive video examination of a patient conducted by physicians separated by hundreds of miles.



Product description

Components of a telemedicine videoconferencing system vary, depending on the configuration chosen by the buyer. In general, system components include a codec, viewing monitor(s), camera(s), control/user interaction devices (e.g., mouse, keyboard,) input devices (e.g., document scanner, medical scopes), and output and storage devices (e.g., printers, CD-ROM drives). Most suppliers offer different configurations customized to the buyer's needs.

Principles of operation

Telemedicine videoconferencing uses video and telecommunications technology to transmit medical information (audio, video, and graphics) between two or more sites.

Operating steps

Patient examinations are conducted using instruments (e.g., stethoscopes, ophthalmoscopes) and examining cameras connected to the telemedicine system, allowing a physician at a remote site real-time access to the patient and real-time interaction with the examining physician, physician assistant, or nurse. A technician or nurse typically operates the instruments with the patient in an examination room. Images and data are then transmitted to the remote physician for viewing and analysis, and interacting with the patient.

Reported problems

The telemedicine system should have some form of security to avoid problems with data confidentiality. Electric fluctuations can damage computer components, impair system performance, disrupt program operation, and destroy data. Preventive measures include installing an online uninterruptible power supply. A dedicated power line isolated for the central processing unit may be useful to reduce signal noise. Copying disks at regular intervals protects stored information.

Use and maintenance

User(s): Physicians, medical professionals, administrators, students

Maintenance: Technicians; IT staff; biomedical or clinical engineer

Training: Initial training by manufacturer and manuals

Environment of use

Settings of use: Hospitals; private practices; clinics; schools

Requirements: Stable power source

Product specifications

Approx. dimensions (mm): NA

Approx. weight (kg): NA

Consumables: NA

Price range (USD): 1,495 - 177,000

Typical product life time (years): 5 to 7

Shelf life (consumables): NA

Types and variations

Mobile (rollabout); group (room); desktop

_________is the delivery of health care and the exchange of health care information across distances
the prefix'tele' derived from greek word means__________
Telemedicine encompases the whole range of medical activities such as
______is a related term that refers to provision of nursing and community support to the patient
_________refers to the provision of public health services delivered at a distanceto people who are unwell.
An umbrella term encompassing all health related activities carried out over a distance by technology is call
_______ is an integral part of health telematics
Videoconferencing is a common method of ________ interaction
Telemedicine episodes may be classified on the basis of
Telemedicine is the use of medical information exchange from one site to another via
Which of the following situations is not considered part of telemedicine?
Telemedicine allows hospitals to optimize the use of their personnel by
Medical related images and simulations available to educate patients is an example of
Health workers in remote areas of the world can communicate with specialists using webcams and
An example of mathematics being used in medicine is
__________________ is the use of medical information exchanged from one site to another via electronic
Which of the following is NOT and example of Telemedicine technologies.
Which of the following is NOT a resource (Input) in the universal system.
Telegraphy (signalling by wires) was used for medicine at a distance which permitted _________to be trans
In _______, a telestethoscope was decsribed which amplified sound from stethoscpe and transmitted via te

Telemedicine	Telehealth	telecare	telehealthc
at a distance	at a far distance	near by	remote pla
diagnosis	treatment	prevention of diseases	all the abov
Telehealth	**telecare**	mobile medicine	none of th
Telehealth	telecare	mobile medicine	none of th
health telematics	telematics	telemedicine	telehealthc
telehealth	**telemedicine**	telematics none of the above	
virtual	face_to_face	**real time**	none of th
interaction between client and exp	interaction between patient	type of information being transm	**all the abo**
electronic communication	verbal communication	written communication	print comn
videoconferencing	remote monitoring of vital	**word processing**	transmissio
cross training doctors, nurses and	**allowing them to take mo**	allowing outside specialists to vi	outsourcin
videoconferencing	**continuing medical educa**	nursing call centers	remote mo
satellites network	security systems	electrocardiograms	fiber optic
taking an x-ray image	taking a blood sample	**the mixing of prescription me**	setting a b
Skype	Videoconferencing	Emergency Room	**Telemedi**
Satellites	**DC Motor**	Databases	Wireless a
Technology	Information	Time	Capital
X-ray	mri	ultrasound	all the abo
1920	1950	1930	**1910**

:are	Telemedicine
ce	at a distance
ve	all the above
e above	telecare
e above	telehealth
:are	health telematics
	telemedicine
e above	real time
ove	all the above
nunication	electronic
on of still images	word processing
ig all possible work	allowing outside specialists to view patient x-rays
onitoring of vital sign	continuing medical education
s	satellites
roken bone	the mixing of prescription medicine
cine	Telemedicine
nd Broadband Intern	DC motor
	Technology
ve	X-ray
	1910

Which among the following is the full form of PSTN?
Which is the component of telemedicine?
The Telemedicine Programme of ISRO is an innovative process of synergising benefits of_______commun
Which among the following is the full form of PACS?
Most of the telemedicine platforms both in public and private health sector in the country are being launche
The Sheshnag telemedicine node consists of
The __________ for this node is in the field of General Medicine, Orthopaedics, Respiratory and Cardiolog
What is the bandwidth of MT-Ronan satellite?
Different telemedicine technologies require different capacities or __________ for communication infrastru
Rural areas in particular have the _______access to high quality and high capacity modern telecommunicat
The fast changing nature of the infrastructure technology itself will dramatically affect the ________ of tel
GSM is a circuit-switched system that divides each ________ channel into eight 25kHz time-slots
__________is a channel access method for shared medium (usually radio) networks.
The mobile station (MS) consists of the mobile equipment (the terminal) and a smart card called the _____
The _____Telecommunications Act requires that the Federal Communications Commission (FCC) and the
In which year, the Sheshnag telemedicine node was established?
________satellites only reflect the signal coming from the source, toward the direction of the receiver.
The high frequency _____________ used for telecommunications links travel by line of sight and so are ob
GSM operates in the 900MHz and _______ bands in Europe
Which among the following is the full form of ISDN?

Public switch telephone network	Private switch telephone netwo
Store and forward	Real time
Satellite	WAN
Picture Archival Communication Server	Picture AccessCommunication
TCS	**ISRO**
Video conferencing	X ray scanner
telecare	**tele-consultation**
112 Kbps	120 Kbps
frequency	**bandwidth**
least	high
efficiency	**cost**
200kHz	400kHz
TDMA	FDMA
Subscriber Identical Module	Subscriber Identity Modem
1995	**1996**
2005	**2006**
Active	**Passive**
Beta wave	infrared wave
1.5GHz	3.2GHz
Integrated Services Digital Network	Integrated Services Digital Net

Public step telephone network	None of the above
Remote patient monitoring	**All the above**
LAN	None of the above
Picture Archival Communication System	Picture Archival Component System
DIT	SISL
ECG machine	**All the above**
tele-monitoring	None of the above
212 Kbps	250 Kbps
phase	All the above
rare	frequent
quality	All the above
500kHz	100kHz
CDMA	None of the above
Subscriber Identity Module	Server Identity Module
2000	1998
2007	2008
mediator	None of the above
microwaves	**radio waves**
2GHz	**1.8GHz**
Integrated Server Digital Network	Independent Services Digital Network

The **Telemedicine Act** ________ensures that only qualified medical practitioners can practice **telemedicin**

____________refers to any laws relating to protecting the Internet and other online communication technologies.

_________________is a modern branch of cryptography. also known as public-key cryptography in which the algori

The telemedicine system should have some form of _________to avoid problems with data confi dentiality.

The encryption key and the decryption key are interrelated in____________

Which among falls under the category of Cyber law?

Video conferencing systems are used for diagnosis and prescription of medical treatment for patients at _________ lo

________________is a mechanism used to encrypt or decrypt a message.

Telemedicine videoconferencing uses video and telecommunications technology to transmit medical information like

___________ have been given legal validity and sanction in the Act.

Digital Imaging and Communications in Medicine is the ____________**standard** to transmit, store, retrieve, print, pr

Encryption is the process of converting a _____________ message into ciphertext which ca

The __________ telehealth software pairs with 4G Samsung tablets and wireless devices

Cyber law is also called as__________

DICOM is actively developed and maintained to meet the _______technologies and needs of medical imaging

A single ___________which is used in conventional symmetric encryption which is used to

DICOM makes medical imaging information

Which among is the important area of Cyber Law?

Patient examinations are conducted using ________ and examining cameras connected to the telemedicine system

An encryption algorithm along with a _______ is used in the encryption and decryption of d

1998	**1997**
crime law	Telemedicine law
Assymetric encryption algorithm	Symetric encryption algorithm
confidentiality	**security**
Assembled encryption algorithm	Assymetric encryption algorithm
Digital Signature Act	Computer Crimes Act
remote	near by
Cipher text	**Cipher algorithm**
audio	video
Digital signatures	Audio proof
international	national
audio	image
HRS	VRS
Information law	**IT law**
evolving	existing
public key	private key
interoperable	robust
Fraud	Copywrite
clinical test	blood test
key	carrier

	1995	1994
Cyber law	All the above	
Assembled encryption algorithm	none of the above	
permission	privacy	
Symetric encryption algorithm	Cipher algorithm	
Communications and Multimedia Act	**All the above**	
global	none of the above	
Chinese Lottery	Counter text	
graphics	**All the above**	
Images	Text	
local	regional	
signal	**plaintext**	
CRS	PRS	
Crime Law	All the above	
old	modern	
secret key	combined key	
flexible	incompatible	
Defamation	**All the above**	
equipment	none of the above	
modulator	none of the above	

___________is the transmission of radiological patient images, such as x-rays, CTs, and MRIs, from on

A ____________is an element of health informatics that focuses mainly on the administrational n

Which among the following is the factor of compression?

Teleradiology utilizes standard network technologies such as the _______________

________________a computer **system** that can manage all the**information** to allow health care

HIPAA (Health Insurance Portability and Accountability Act of _________) is a uniform, federal floor of p

When HIS is implemented well, cuts out on a lot of _______ work that are essentially performed in hospit

Teleradiology expanded rapidly as the growth of the internet and broad band combined with new______

Retrieve-ability of data stored on a ________gives quick access data.

Teleradiology cost starts at about __________per day.

Improved access to patient data and improved work efficiency means better and faster

Teleradiology	Telepathology	
hospital information system	Medical information system	
Transmission of images	Storing of images	
internet	telephone lines	
hospital information system	Medical information system	
1998		1995
computer	**manual**	
X-ray	**CT**	
Clouid	CD	
$1,500		$2,500
Clinical decision	Health care	

teleoncology		none of the above
Pharmaceutical information systems		All the above
baud rate reduction		**All the above**
local area network		**All the above**
Pharmaceutical information systems		All the above
	1996	1978
digital		None of the above
MRI		Ultrasound
Harddisk		All the above
	$5,000	$8,000
Quality care		access to information

__________________ is the use of medical information exchanged from one site to another via electronic c
Which of the following is NOT and example of Telemedicine technologies.
Which of the following is NOT a resource (Input) in the universal system.
Telegraphy (signalling by wires) was used for medicine at a distance which permitted _________to be trans
In _______, a telestethoscope was decsribed which amplified sound from stethoscpe and transmitted via tel
The mobile station (MS) consists of the mobile equipment (the terminal) and a smart card called the _____
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Skype		Videoconferencing	
Satellites		**DC Motor**	
Technology		Information	
X-ray		mri	
	1920		1950
Subscriber Identical Module		Subscriber Identity Modem	
	1995		**1996**
	2005		**2006**
Active		**Passive**	
Beta wave		infrared wave	

Emergency Room		**Telemedicine**
Databases		Wireless and Broadband Internet
Time		Capital
ultrasound		all the above
	1930	**1910**
Subscriber Identity Module		Server Identity Module
	2000	1998
	2007	2008
mediator		None of the above
microwaves		**radio waves**