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A Conceptual Model of Biomedical Network in DRDO

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ABSTRACT

Easy and timely availability of comprehensive information catered to the specific needs of the user is the blood of R&D activities in biomedical field. For the successful accomplishment of the highly specialised, multidisciplinary programme, the necessity of having an advanced IT-oriented infrastructure is indisputable. The need to access current and relevant information transcends the boundaries of the libraries/technical information resource centres (TIRCs). Though many computer-assisted communication technologies are available, their provisioning requires a substantial commitment of resources in terms of staff expertise, computer hardware (H/W) and software (S/W) and training, which may not be adequately available at all TIRCs. Recognising the criticality of the need to access current biomedical information, the authors have conceptualised the establishment of an advanced informatics centre for biotechnology under 'Microbiology 2000' programme of the Defence Research & Development Organisation (DRDO). The proposed facility is planned to be established with the technical and professional help from librarians, information technologists and subject specialists from life sciences laboratories of DRDO. The facility is visualised as a technology group that will perform the dual role of being the facility centre as well as the design centre. In the second phase of the proposal, the facility may be thrown open for commercial exploitation. Institute of Nuclear Medicine & Allied Sciences (INMAS) can play a pivotal role in this cooperative effort for creation of this facility, which is expected to tremendously improve capabilities in information handling and customised services specially in the field of telemedicine.

1. INTRODUCTION

Resource sharing has a long and noble tradition. Recently, it has become a focus of interest to the librarians and information professionals. This can be seen from statements, such as 'pride in collection has got to be supplanted by pride in patronage', 'libraries should think materials as community resources', 'local ownership to collective access', etc[1]. Further, the terms like consortium, network, and cooperatives have been used to label the organisational arrangements for achieving a variety of resource sharing objectives.

In recent times, networking has transcended from cooperation among libraries and information centres to cooperation with the book trade[2]. This has stimulated e-mailing within the context of document delivery services. As data and information transfer is increasingly becoming easier and common due to the upsurge of network facilities and capability, network users can conveniently choose any one or more available routes to access any document. Similarly, cooperation among biomedical libraries and information centres has received further boost with advances in computer and information technologies[3]. The telecommunication technology, particularly the satellite communication, has technically compressed space and time. The gradual shift from analog

to digital in contrast to analog links facilitates the integration of all forms of information communication within network environment. These links serve to maximise access and utilisation of materials and services of the participating libraries and information centres in a coordinated network environment at local, zonal, regional, national and international levels.

Literature survey on library cooperation and networking reveals that the US Library of Congress (LC) is on the top in the list of success records and Online Computer Library Centre (OCLC) and other libraries and technical information centres follow later. The UK ranks second with the success achieved by BNB, BLOMP, LASER, etc. In India, Calibnet, Delnet, Bomnet, Malibnet, Adinet, Punenet, Balnet, Mylibnet, and Inflibnet library networks are the existing attempts in this direction[4].

2. NEED FOR AUTOMATED LIBRARY & INFORMATION SERVICE NETWORK SYSTEMS

Advancement in science and technology has given rise to proliferation of scientific literature and information and the same holds good for biomedical and allied sciences, including areas like toxicology, food technologies, agriculture, materials, biomedical devices and instrumentation. No library or information centre is self-sufficient by itself. Therefore, resource sharing among libraries is a necessity.

Cooperation among libraries and information centres is largely necessitated because of the following reasons:

(a) Continued information explosion

(b) Rising demand for information access

(c) Gradual decline in the provision of financial, human and material resources.

In response to these demands, libraries and information centres are engaged in cooperative ventures of all forms, such as interlibrary loan, exchange, cooperative acquisition, processing and storage, etc[5].

Library's decision on adopting a network and choosing appropriate type of networking systems is a function of several parameters as mentioned below:

(a) Type of special services to be offered by the network. These may include electronic mail and CD-ROM product utilisation

(b) Capability of the network systems to accommodate new developments

(c) Whether the facilities offered by the network can be integrated with other information technology appliances in the library

(d) Reliability of the network services including those of the central and zonal/regional computer facilities

(e) Cost of membership participation versus anticipated benefits

(f) Number and type of libraries participating in the network and the extent of overlapping in the strength of their collections and services to support record and resource sharing

(g) Security of the data on the net and access to only authorised persons.

3. IT REQUIREMENTS FOR BIOMEDICAL SCIENCES & TECHNOLOGIES IN DEFENCE

Re-emergence of infectious diseases, availability of biological and chemical weapons as cheap deterrents, terrorist activities, nuclear capabilities of hostile neighbouring countries and the high cost of imported biotechnologies has prompted the Defence Research and Development Organisation (DRDO) to take up an integrated programme for the development of latest biotechnologies in a big way.

To cater to the bioinformatics requirement of the scientists, it is planned to share the scarce and costly information resources. An advanced bioinformatics centre is planned to be established at the Institute of Nuclear Medicine & Allied Sciences (INMAS). The prime objective of the proposed Biomednet is to set up a secure biomedical network connecting life sciences laboratories of DRDO and decision makers in DRDO HQrs. Also, sharing resources with few non-DRDO information centres of repute is envisaged.

DRDO is setting up a nationwide network of its laboratories and HQrs called DRDO's rapid online network access (DRONA) system. This internal corporate network is based on

integrated systems digitised network (ISDN) services provided by the Department of Telecommunication (DoT). Alternative services like Dialup/INET/VSAT will be used where ISDN services are not available.

Since DRONA will operate behind firewalls, it will be possible to access the Internet while protecting organisation's data from unauthorised non-DRDO personnel. Major benefits of such a network include powerful data management, ease of use, cost efficiency and dynamic workgroup exchange[6].

Network requirements of DRDO life sciences laboratories can be summarised as follows:

(a) Provision of resources for the biomedical databases—this comprises bibliographic/full-text databases on CD-ROMs/DVDs and other existing online databases, besides generation of databases of defence interests

(b) Resource sharing through databases

(c) Providing easy access to these databases through DRDO's network for the laboratories located in Delhi and at distant geographical locations, maintaining network security

(d) Supporting all existing computer hardware and software

(e) Implementing data archiving and disaster recovery

(f) Increasing the speed at which information can be shared by users

(g) Supporting collaboration through groupware and e-mail.

Appropriate databases will be created for answering various queries in specialised disciplines.

3.1 Technical Features of Data to be Transmitted

Besides data in textual form, images files e.g., X-ray, CT, nuclear scintigrams and MR images will be transmitted across DRDO's biomedical network. Electronic transmission of these radiological images from one location to the other will be desirable for secondary consultations. Users at different locations may simultaneously view images. Appropriately utlised, this technique can improve access to quality radiological interpretations and thus significantly improve patient care. This may allow even more timely interpretation of radiological images and give greater access to secondary consultations and improvement in continuing education.

Many service providers deliver their services using satellite technology and through public telephone lines. ISDN is similar to the current public telephone lines. However, ISDN is digitally coded which allows for more varied use. For example, through the public telephone network, though the voice, facsimile and data transmission services are available, yet these services are limited by speed and signal complexity. In ISDN services, signal compression occurs that allows for voice, data transmission, video, and facsimiles to operate simultaneously. Thus, one call can replace several calls for the same service. Besides, ISDN lines are faster and more efficient than the currently available public phone network. However, in near future, we may see phone companies upgrading their systems to allow for the ISDN because this service can be easily installed without phone companies having to replace their entire system. Rather replacing all their phone lines, all they have to do is to buy and install new switching equipment and interface devices that connect the customer on a telecommunication network with video channels having the capacity to send signals 'upstream' to a cable company or whosoever is disseminating the programmes. Unlike the current cable service, this system will be of the quality of a 35 mm movie film and it can simultaneously provide mixes of voice, text, graphics, and moving image displays that qualifies it as multimedia.

4. PROPOSED BIOMEDNET INFORMATION SYSTEM

4.1 Architecture of Biomednet

Schematic network configuration of the metropolitan area network (MAN) of Biomednet is shown in Fig. 1. The overall architecture of Biomednet may be viewed as involving two types of networks[7,8].

Table 1. Software solutions available

Product	Features
Novell's NetWare 4.1	Fastest file server, stable operating system (OS)
	Provides sophisticated directory and security services and true multi-server support
	Though there are many graphical tools for administrating the network, the server console is command line interface
	Cannot execute programs on the server that are not specifically designed for NetWare. Runs programs written only for NetWare
Microsoft Windows NT 4.0	The OS is designed not only for Intel-based computers but also for computers using RISC microprocessors, such as Power PC, MIPS, Digital Alpha, etc. It is a platform-independent OS
	Pervasive security mechanisms
	Provides fault tolerant environment for execution of programs and services
	Supports most client OS such as DOS, Windows, OS/2, and the Apple Macintosh. Provides network file services for Unix computers, which are not classified as clients
	Graphic server console interface
	Server can be used for running applications
Banyan Vines	Runs on top of a host OS such as SCO Unix. The host OS performs the functions of controlling the hard disk drives, memory and the network interface. Banyan Vines implements the protocol by which client computers are granted access to the file storage provided by the host OS.
	First PC-based network environment to provide sophisticated directory services with true multiple-server support
Unix	It is not a single OS but rather a name for a family of related OSs from various companies that have a common heritage and functionality. Like Windows NT, the various versions of Unix are complete OS, they can run applications as well as network services. Unix does not differentiate between clients and servers. Unix can also be a server to other client OSs such as Windows 95, DOS, Mac and NT
	Most versions of Unix like NetWare present a command line interface. However, with X-Windows, which is similar to Microsoft GUI, one can have as many command line interfaces as one wants

(a) INMAS local area network (LAN) providing computer-generated communication within INMAS campus, and

(b) DRONA providing biomedical communication to the life sciences laboratories of DRDO across the nation.

The software and hardware solutions available are shown in Tables 1 and 2, respectively.

4.2 Security of Biomednet

In the post-Pokhran II scenario, 'electronic molestation' of the network of Bhabha Atomic Research Centre, country's premier atomic energy establishment, came as a shock to all. DRDO cannot afford similar act performed by hackers guided by either a spirit of adventure or as an attempt to steal or alter data. The form of attack may also include introduction of macrovirus or 'denial-of-service', resulting in

Table 2. Hardware requirements for Internet server

Suggested configuration	Comments
Intel 233 MHz processor	Internet servers are almost never CPU-bound. Routing to low bandwidth connections is also not very taxing
RAM 128 MB	Minimum 64 MB, 128 MB is recommended for Intranet server
HDD 2 GB	Web sites are rarely very large. Sufficient for Windows NT 4.0 server and Intranetics 97 (designed to enable small and medium-sized organisations to enjoy the benefits of a large company intranet)
MO 2.1 GB	For backup hard disks
Network adapter	Fast Ethernet for Intranet servers
CD-ROM 24 X	For loading software
Special hardware	Web server will be leased line constant connections to the Internet with T-1 interface

overtaxing of the system resources. Therefore, some precautions need to be taken and appropriate measures have to be devised to secure the network against hacking, to prevent unauthorised use of computer and networking system and access to vulnerable and highly sensitive data. This will prevent serious monetary and image losses. The security for the network has to be reliable. The role of the user of the network is to observe certain netetiquette like not to communicate with dubious people, not to open unidentified mails with vague messages, choose less-obvious passwords and avoid installing unauthorised software. Strong encryption technologies, virtual private networks and firewalls are expected to improve the overall security of network systems. Suggested configuration of firewall is given in Section 4.3.3.

4.3 INMAS as a Nodal Point for Biomednet

4.3.1 *Local Area Network*

The conceptual model of Biomednet is shown in Fig. 2.

INMAS's LAN is based on the following hardware and software. Windows NT 4.0 server is used mainly due to its platform-independent OS and the fact that it can be used for running applications. It will enable the scientists to access information from Biomednet.

Server: Intel P-II 300 MHz, RAM 64 MB, HDD 3.1 GB, fast Ethernet adapter, Microsoft BackOffice (Windows NT 4.0 server, Microsoft SQL server, Microsoft exchange server, Internet information server, IIS, Systems management server)

Workstations: Intel P-II 233 MHz, RAM 32 MB, HDD 2.4 GB, fast Ethernet adapter, Windows NT workstation 4.0 (5 nodes)

Cabling: Unshielded twisted pair, category-5

Hub: Fast Ethernet

CD-ROM/DVD Towers: 14/28 bay CD-ROM/DVD towers will be used for storage of multiple diskettes (CDs/DVDs) of routinely used biomedical databases. All the discs or the selected discs will be accessible from any workstation and all the users on the workstations of the LAN can access the database simultaneously. The device is Intranet-ready which enables its accessibility from distant nodes on the Intranet. These towers off-load traffic from the file server and use familiar commands to access CDs. CD- ROM towers can be monitored from any network station. The factors affecting the performance of a CD-ROM tower are:

- CD-ROM drive characteristics (double speed or quad speed, etc.)
- Controller type (SCSI, IDE, Parallel port connection)

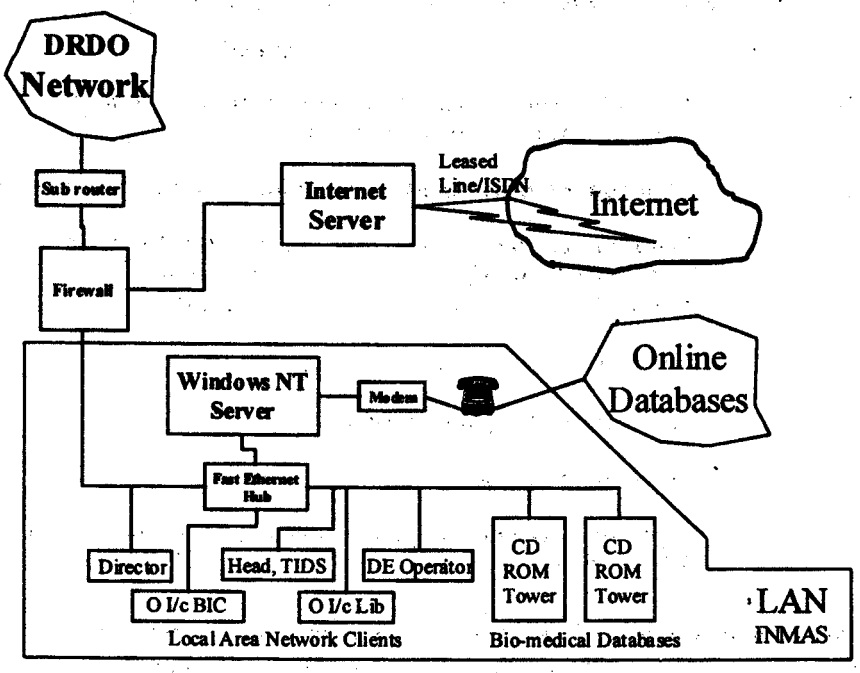

Figure 1. Architecture of Biomednet at Delhi

- Amount of RAM available in the workstation for caching
- Speed of the workstation running the CD-Manager

Peripherals: Printer Laser 5P, Modem 64 kbps, MO 1 GB for backup, scanner for scanning of images (reflection and transmission)

4.3.2 *Internet Server*

An Internet server is the special application server that will answer hypertext transfer protocol (HTTP), file transfer protocol (FTP), and Gopher requests from the Internet. Interne servers allow organisations to publish Wel pages on the Internet, post information files anc programs. Uniform resource locator addresse: are the addresses to Internet servers.

The IIS package that comes with Window: NT server 4.0 provides all the functionalit necessary to use a Windows NT server as ar Internet server. It provides secure storage anc publication of HTTP, FTP and Gophe information from the Windows NT Server anc keeps Internet traffic securely separated fron other information on the server. However, the

Table 3. Hardware requirements for firewall

Suggested configuration	Comments
Intel P-II 266 MHz	As firewalls are usually attached to slower bandwidth connections, speed is not a big issue
DRAM- 64 MB	No need for large caches on firewall hosts
HDD-3.2 GB	Sufficient for OS and firewall
Fast Ethernet adapter with 3 RJ 45 interface	A network connection for the internal network is needed
CD-ROM	For loading software

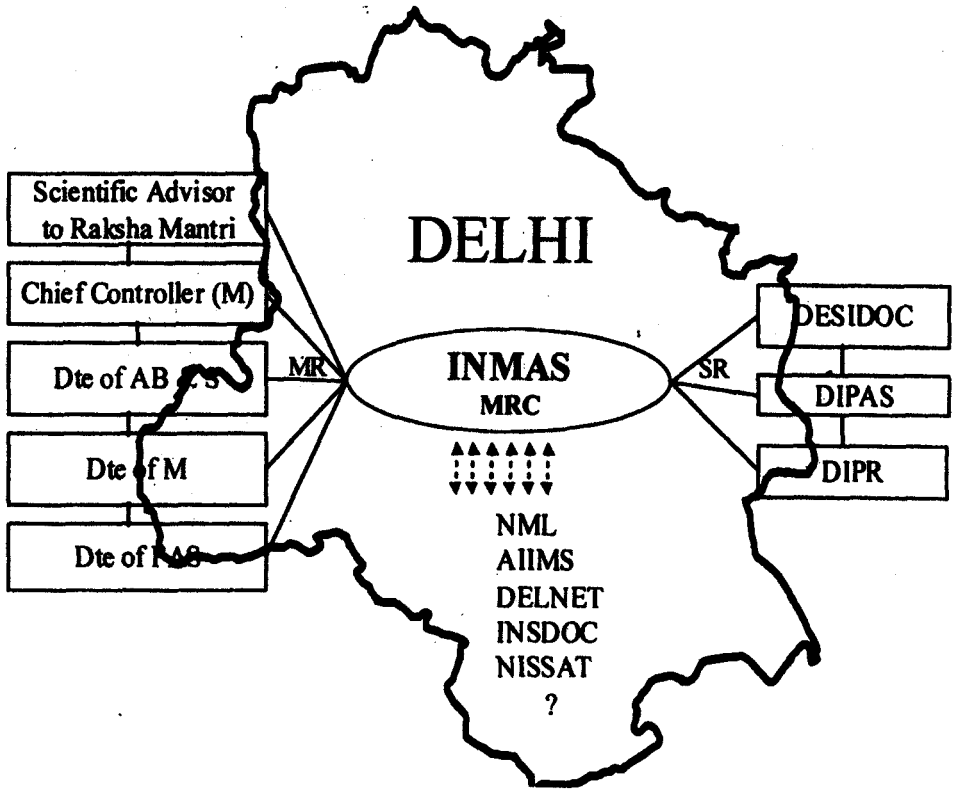

Figure 2. Conceptual model of Biomednet

IIS cannot keep away the hackers from penetrating other computers on the network. Therefore, a firewall is required to be placed between the Internet server and the in-house network. This means that, for the most part, secure data should not be stored on the Internet server.

The Internet server will be connected to the Internet service provider (ISP) through a dedicated leased line of 64 kbps with a TCP/IP connection[9].

4.3.3 *Firewall Configuration*

Since networking is based on ISDN provided by DoT, it is necessary to provide a security mechanism for checking unauthorised accesses. Denial of access to unauthorised users will be achieved by access control and authentication, which is one of the ISDN services provided by DoT. It ensures that access to DRDO network cannot normally be made from telecom lines other than listed. In addition, firewalls will be used.

Firewalls are the security gateways that protect networks connected to the Internet from intrusion (called 'attack' in security circles) by unauthorised parties. A firewall is the only computer on the internal secure network that is attached to the external non-secure network (the Internet). The firewall acts as a proxy for each client on the internal network, hiding its identity and exposing only a single IP address to the Internet. The firewall performs many other security services, such as checking IP addresses for permission to access the internal network and denying access to unlisted addresses[10].

One should never run services other than the firewall services on a computer acting as a firewall. The reason is that hackers may be able to exploit bugs in ones software to bypass the security functions of firewalls. Since the firewalls can't be used to perform other services, they need only be faster than the fastest network connections attached to them and have enough disk space to store the firewall

software. Windows NT 4.0 workstation as the OS platform could be used as the firewall for accessing 10 simultaneous IP connections.

4.3.4 *Main Routers & Sub-Routers*

Biomednet will have two levels of connectivity. Integration plan of the MAN of Biomednet with the nodes of interest in DRDO network is illustrated in Fig. 3. INMAS will be the main router centre (MRC) with more ports for connectivity. The sub-router (SR) will be connected to the main router (MR) at INMAS MRC of DRONA via ISDN or Dial-up/INET/ VSAT. The SR place at each TIRC of the SR centres connected on Biomednet, will have one LAN port, one ISDN port and one wide area network (WAN) port. The LAN will be connected to the SR through the LAN port via a firewall.

4.4 User Workstation Requirements

1. A computer having operating system that can run a web browser.
2. A frame-capable browser that supports the ability to upload files, such as Netscape Navigator 3 or higher or Microsoft Internet Explorer 3.02 or higher with file upload add-on.

5. CONTEMPLATED ROLE & UTILITY OF BIOMEDNET

DRDO's DRONA connecting all the 54 DRDO labs spread over 23 places in the country, apart from DRDO HQrs at New Delhi will be the WAN for Biomednet as illustrated in Fig. 3. The data and resources available on network will be accessible to geographically separate users. INMAS's LAN will be interfaced with *DRONA* using the IP/IPX protocols on a

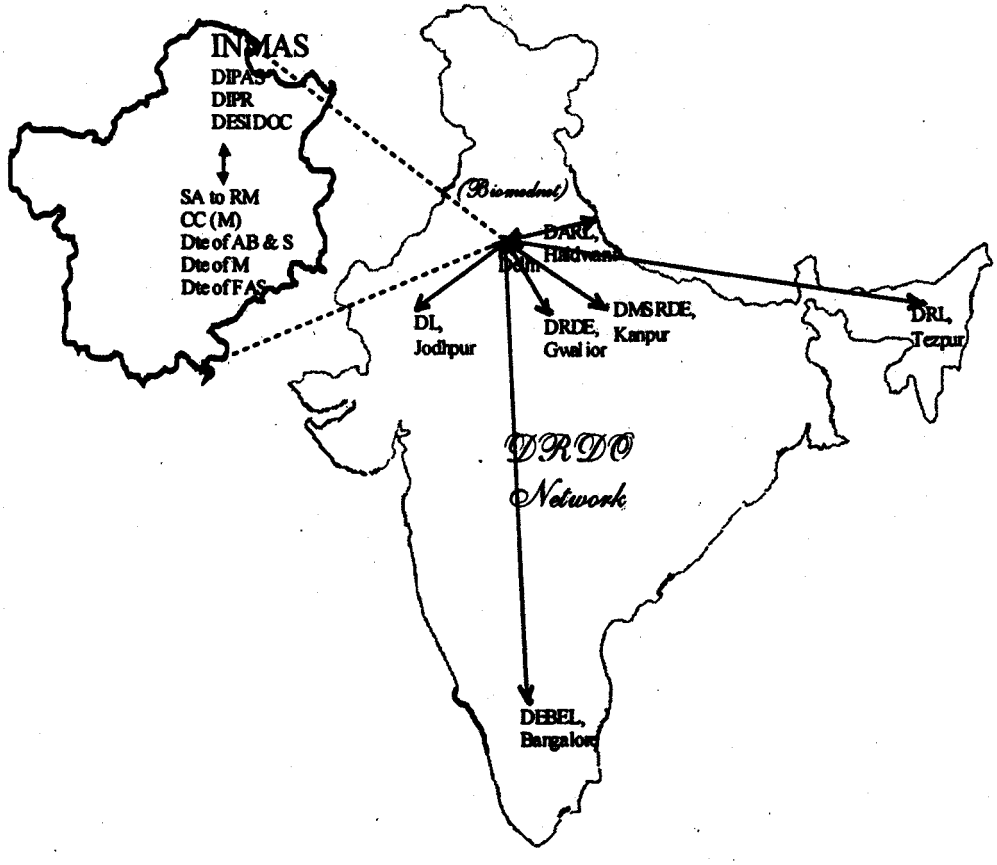

Figure 3. Integration plan of Biomednet with other nodal centres in India using DRONA as the backbone

10/100 Base-T Ethernet interface. Once established, the automated networking under Biomednet will facilitate the provisioning of following services:

- Access to the participants' collection, services and databases through, say, open access catalogue (OPAC) interfaces
- Knowing the content of the participants' catalogue, databases particularly on CD-ROM, whenever and wherever it is required
- Library and information service users' access to other databases available on say, online hosts, CD-ROM or via OPAC
- Exchange of indexes and bibliographic records, particularly using CD-ROM facilities
- Publication and distribution of electronic documents in different forms and texts
- Access to journals available in electronic forms
- Exchange and sharing of documents and other related library and information services among the cooperating members, including sharing expenses and tasks involved in creating and sustaining databases
- Provision of specialist services, such as electronic mail (e-mail), file transfer, and directory services within the frame of document delivery services, both in normal and encrypted modes
- Designing of a virtual database of defence related biomedical information
- Timely retrieval of the information of defence interest.

5.1 Telemedicine

Telemedicine is combining telecommunication technology with medical expertise for the delivery of medical care and education without regard to location. This concept will be useful for remote medical consultations, as this will minimise patient's travel to expensive tertiary care, continuing medical education and will result in delivery of quality medical care for the benefit of all. Specific applications of telemedicine include:

- Electronic management and transport of patient information and records for diagnostic purposes
- Image compression for efficient storage and retrieval of image date
- Image processing for diagnostic purposes
- Electronic processing of health and medical claims
- Electronic inventory to support community healthcare organisation
- Teleconferencing for professional training, education, and consultations
- Digital transmission of large 2-D and 3-D medical images
- Computerised control of medical equipment via the national information infrastructure.

DRDO Health Centre can contribute a lot once this facility is operationalised.

5.2 Teleradiology & Telenuclear Medicine

Teleradiology is the electronic transmission of radiological imaging from one location to the other for the purpose of interpretation and/or consultation. Teleradiology is the application of digital technologies of telecommunication and information management technologies for electronic transmission, display and management of radiological images from one location to the other. Thus, it will be an on-call facility without on-site support to provide timely and quality consultative and interpretative services. There will be greater access to secondary consultations and this will also permit simultaneous viewing of images at different locations thus improving patient care and continuing education. These services will be much in demand in view of the excellent infrastructure in the field of nuclear medicine and radiological imaging available at INMAS.

6. IMPLEMENTATION PHASES

The Biomednet facility is proposed to be implemented in two phases. In Phase I, after linking the TIRCs of life sciences, food, agriculture, material and biomedical labs of DRDO, a strong group of information specialists and subject specialists will be constituted. The Biomednet facility is visualised as a facility centre and a design centre. Timely information exchange on the Biomednet will be

initiated, followed by generation of databases of DRDO's interest.

In Phase II, the facility will be thrown open to chemical and pharmaceutical industry and health services for commercial exploitation. Faster communication channels (like VSAT links) are planned besides improving the network parameters and software.

7. CONCLUSION

It is true that under-utilisation of the library collection is largely due to the users not getting the information in time. If a reader comes to know the availability of documents required by him, and also if he can get access to them quickly, it would not only optimise the use of library collection but also would effectively contribute to the S&T efforts in the country. Faster and reliable communication system and information technology has opened new vistas for resource sharing between the generators and users of information. Networks provide a number of navigational tools and associated services, which could be used by libraries to access resources at remote places for browsing, searching and even downloading. Networking movement is redefining the concept of collection, collection development and transforming the selection, preservation, communication, and liaison functions in libraries. A powerful new context for the theory and practice of collection management and requiring librarians to develop new skills, accept new responsibilities, and change their ways of performing various library operations is fast emerging.

The proposed Biomednet is expected to bring immense contribution in information sharing in DRDO. Once fully operational, the facility may also be open for commercial exploitation and interaction with the academics organisations.

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