EHB Data Communications and Networking Strategy for the 1990's

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CONTENTS

Introduction 1

EHB'S Current Computing And Network Configuration 2

Consideration Factors 4

Client/Server Architecture And The Extended LAN 6
   Client/Server Model 6
   Extended LAN 7

Protocols And Standards 10
   ISO/OSI 10
   TCP/IP 13
   Transition from TCP/IP to ISO/OSI 18
   Network Management 21

Public Services 22
   ISDN 22
   MAN 24

X-25 25

Frame Relay 27

Mobile Data Communications 28

Present EHB Applications To Be Considered 29

Conclusions 32
This study has been undertaken to determine the Board's future networking requirements. The current network has been satisfactory and very adequate to date. However, there are new technologies and services that the EHB may wish to avail of now and in the future.

I have looked at the factors that have arisen and will arise in the Computer Industry and Telecommunications Industry and the implications they will have in the EHB framework if there is a need to adopt them. The study encompasses the following aspects:

1. Client/server technology as well as the extended LAN scenario and the implications it will have if adopted by the EHB.
2. Protocols and what they mean to the EHB. OSI and TCP/IP have been looked at in this context.
3. Printing and its implication over the network.
4. I have taken cognizance of planned application developments and their networking implications.
5. Telecommunications services that will be offered in the not too distant future and how they may fit into the EHB strategy.

The aim is that a dynamic and flexible data network be designed so that the EHB may avail of technologies and services as they arise and need to be adopted into the Board's framework.
EHB'S Current Computing and Network Configuration

Current Computing Environment

The Eastern Health Board's Computer environment consists of a number of DEC VAX's running the VMS operating system. These systems are mainly centrally based and are accessed by asynchronous terminals or PC terminal emulation. The number of asynchronous terminals in the wide area and local area is currently in the order of 600. Currently all data resides on flat files or a Codasyl dbms database and is mainly located on our central computer systems.

In addition to VAX computing, the EHB has a sizeable amount of IBM compatible PC's running the DOS operating system and Microsoft Window's 3.1 as it's Graphical User Interface (GUI). Apple Macintosh workstations are also used and runs the System 7 operating system with it's own GUI. The number of Mac/PC users is approximately 300 and growing.

At present, the majority of these workstations are standalone devices. However, some PC's are networked using Novell Netware while some Macintoshes are networked using Appletalk. The networks tend to be used for Office Automation or local systems such as the Cashflow System, Pharmacy System etc. To date these systems have remained standalone and have never been inter-networked.

Current Network Environment

The current Eastern Health Board Network is primarily an asynchronous terminal access network. The network uses Series 300 DCA Switches and Multiplexors. It allows for:-

- Circuit Switching (as opposed to packet based networking)
- Host Selection
- Alternative Routing in event of link failure
- Loading balancing of multiple links
- Protocol Conversion
- Allows multiple 64kbps links between DCA 300 Switches

Users in small to medium size remote sites are serviced by Series 100 Statistical Multiplexors. The Series 100 supports up to 32 async ports on a single 14.4 kbps (max) trunk link.

The network currently has 10 Series 300 Dataswitch Nodes and approximately 40 Series 100 Statistical Multiplexors. All intermodal and feeder trunk link speeds are between 2400 bps and 14.4 kbps. This type of equipment is primarily used for wide area connectivity.
On the Local Area Network front, our networking strategy is based on the Ethernet/IEEE 802.3 standard. A Bus and Star topology is employed for networking the Vax Computers and workstations.

The different types of media employed to run Ethernet consist of:

- Thick Wire Co-axial Cable
- Thin Wire Co-axial Cable
- Unshielded Twisted Pair Cable
- Fibre Optics

The main high level protocols which exist at the Datalink, Network, and Transport Layers are as follows:

- SPX/IPX Novell Netware.
- LAT Terminal Access to VAX's.
- Decnet Inter Vax Communications.
- Lanpro Inter dataswitch communications.
- X-25 Eirpac Used to access hosts and other networks outside EHB.
- Appletalk Used for MAC Networking.
Consideration Factors

PC/Micro Era

The relative low cost of hardware, the wealth of low cost of software packages has made for an increase in demand for PCs in the Board. It is expected that this growth will continue. At this stage, however, the majority of PCs are not networked due to the fact they are geographically spread and there has not been a need for networking to date. The bigger sites such as Dr Steeven's Hospital and some of the Hospitals have small PC networks. They are mainly used for specialist applications.

As the population of PCs rises at the various sites the need for networking will grow e.g. E-mail, file transfer, client/server applications. With the supply of portable PCs and notebooks, for instance, it may be advantageous for Community Care professionals to write up their field notes and then once a day/week return to base and download their data to a database. This could also be achieved by dialling in from home via a modem link. In the future, this could be achieved from the field via Mobile Data Communications.

Multi-vendor Computing

UNIX mini/mainframe machines especially RISC machines from different vendor's cannot be ignored. Not only are they very price competitive with VAX's, they also have computer performance advantages. In addition, the EHB will want to take advantages of software packages that may be offered only on a UNIX platform.

Note:- UNIX comes in many flavours which fall into two camps i.e. Open Systems Foundation (OSF) and AT&T System V Release 4 (SVR4).

Database Systems

The board has plans for a client database which most likely will be a relational database e.g. DEC Rdb, Sybase, Ingres, Oracle, Progress. The type of database, the platform it is build on, the access methods, and the underlying protocols need to be chosen. At this point I suggest that a decision on one aspect will determine the others. Another possibility stemming from relational databases is Client/ Server Architecture. In some cases it may well be desirable to support this architecture. I will discuss this in more detail later.

Public Communications Services

ISDN

It is expected that Telecom Eireann will introduce ISDN from late 1993. It will allow users access a wide range of services via a single socket. In short ISDN will extend the digital network to the customers premises.
The services offered via ISDN are as follows:

**Bearer Services:**
- Circuit Mode: 64kbps unrestricted
- Circuit Mode: 64kbps speech

**Teleservices:**
Built on the bearer services which would include telephony, telefax, telex, videotex.

**Supplementary Services:** Examples of these facilities are
- Call Line Identification
- Advice on charge
- Direct Dial Inwards
- Conference Call
- Terminal Portability

**MAN**
Integrated broadband communication has come about with the introduction of 140mbps metropolitan area network (MAN). Over the next few years, the system will be extended round the city. International connections to other broadband networks are also scheduled.

**Frame Relay**
Telecom Eireann hope to be providing a Frame Relay Service in the future. It is much faster technique than X-25 as there are no X-25 style checks and balances enroute.

**Local Processing**
Because of the reduction in hardware and software costs it may be of strategic advantage to move some processing to the user base. For example, it may be advantageous to have local processing in some of the hospitals. It would make the hospital more autonomous giving the user base better performance levels; applications suited to the local environment could be taken advantage of; disaster recovery i.e. Dr Steeven's could act as backup to remote sites and vice versa; reducing affect of outside factors e.g. communications lines, activity at remote site.

**EHB Organisation**
It is important to note that the EHB from a networking perspective is difficult and complex and this is mainly due to the fact that the majority of EHB sites are small and dispersed. This trend is continuing with the decentralisation of the Psychiatric Services. The larger sites such as the General Hospitals and the medium sized sites such as the Community Care HQ's are in the minority. In addition the EHB is made up of numerous and diverse professions with different work patterns and disparate information needs.
Client Server Architecture and the Extended LAN

Client/Server Architecture

Up to recently most LAN networks file servers handled a workstation's database query by sending the entire database file across the network to that workstation. When the workstation completed sorting the database and making whatever changes it needed to make, it returned the information to the file server.

This traditional LAN approach has several problems:

1. Network congestion increases as more and more workstations request that the program and its files to be sent and then send information back to the file server.

2. Network Overhead can be a problem with this approach because a database program might need to create several different processes to permit multi-user operations.

3. Data integrity also might be an issue with so many files travelling through the network.

Client/Server computing may be the answer and is described as follows:

A "front-end" client application program accesses a "back end" server. Several different types of client front-end applications (spreadsheets, accounting programs, project management programs etc) can access the back end server.

The front-end application program processes the information it requested and displays it on its screen; meanwhile, the back-end server program maintains the database's integrity and ensures the network functions with optimum efficiency.

The diagram below illustrates a typical client server relationship on a LAN. Client workstations will have a graphics interface that will simplify many of today's complex database requests. The server has software to sort records as well as perform other server-related functions as communicating with other database servers.

![Client Server Diagram]
Some Advantages of Client Server

1. Workstations do not need the power and processing speed necessary to run the programs efficiently because back end processing is used.

2. It reduces traffic on the LAN significantly.

3. It is easier to write a client server application and then simply write new front ends and for instance, use appropriate remote procedure calls (RPC's) to link the front end with the client server. The remote procedure call provides location and transport transparency and hardware independence in a multivendor network. You use RPCs to target each part of an application to the type of computer for which it's best suited, be it a Macintosh, VAX or 486 system.

Client/Server can be implemented by using one of several interfaces i.e. NetBios (IBM PC), RPC, SPX/IPX (Novell), TCP/IP Sockets (UNIX), Named Pipes (OS/2) and Mailshot.

It must be noted that it is technically possible to use RPC's to transform any application into a client/server system, but you wouldn't want to put small, fast executing routines in a server. The time spent in communicating the data back and forth would overwhelm the application and cause severe degradation. The applications that tend to be most suitable are calculation-intensive or I/O intensive routines.

The Extended LAN

This is a method of linking remote LAN's and local LAN's together into one logical LAN. For example, a LAN based in Naas General Hospital can connect to a LAN based in Dr. Steeven's Hospital or JCM and vice versa. It is transparent to the user where he is connected. Nondeterministic Ethernet LAN's run at 10 mbps. The link that connects LANs over the wide area range from 9600 bps up to 2 mbps. Devices used on this network are as follows:

- Bridges
- Routers
- Brouters

The extended LAN scenario should be followed for the following reasons:

- Inter LAN connectivity - There may be a need for users in one site's LAN to connect to services on a remote LAN e.g. access of files, host based sessions etc.
- Client/Server access over the Wide Area
- **Dumb Terminal connectivity as well as PC LAN connectivity.** DEC's LAT protocol is not very efficient over a wide area link due to synchronisation and prioritisation problems. TCP/IP is supposedly better over the WAN.

- **PC E-mail connectivity**

- **Host connectivity** - for example UNIX and VAX hosts can be interconnected efficiently.

Client/Server Architecture is very much designed to take advantage of the local area environment. However, client/server can be brought to the wide area using bridge/router technology. It must be recognised that the transport mechanism used by Client/Server are protocols that normally reside on a LAN (packetised information) and because of their nature have a fair degree of overhead e.g. source and destination addresses, cyclical redundancy checks (CRC's) etc. Therefore, how efficient a Client/Server application runs over the WAN is very much dependant on:

- The technical framework on which it is built. The database system needs to be carefully chosen as it affects the choice of the underlying protocol.

- How the Client/Server Application is written. Even with client/server, if a screen of data is required for a selected record in a remote table, it may be wise to limit the information displayed to data that is essential. Rarely used data should be relegated to a sub-screen ensuring that only the minimum volume of data is passed between offices.

- What Protocol is being used. As already outlined the protocols supported is determined by the database system chosen. Protocols such as TCP/IP, DECnet, XNS, SPX/IPX have different performance levels over the WAN.

- The amount of online activity. Intermittent data requests or constant data requests has a bearing on performance.

- The communications link over the wide area. The greatest bottleneck in the WAN will be the communications channels. High speed links are expensive and will limit exactly which applications may be feasible. However, sensible regionalisation of databases will improve the situation and overnight updates may be possible for certain applications.

It is suggested that between 4800bps and 9600 bps typically is needed per concurrent user of a Client/Server application e.g. 10 concurrent users from the same remote site would equate to a 128kbps line.

For example, if one of our Hospitals had 20 concurrent users to a remote client/server application, 20 traditional dumb terminals users, routing of 5 Health Centre Sites, bandwidth greater than 128kbps back to Dr Steeven's Hospital would be required. Another point to be made is that all traffic back to Dr. Steeven's would also be a loading on the Steeven's LAN.
If it were decided to have Client/Server over the WAN, the applications would need to be chosen carefully. For example, if access is required to a Client/Server application from the General Hospitals and the Health Centres, there is no uniform method of networking these sites without investing in bridge/routing equipment and the appropriate leased line (ISDN may go some way in assisting this aim whenever Telecom come to implement it). There are methods such as SLIP (IP over serial lines) and pcANYWHERE to link a workstation from a remote site but should be regarded as stop gap solutions and nothing more.

As the Eastern Health Board has a sizeable population of dumb terminals, there is a distinct possibility that an amount of dumb terminal users will need to access the data served by the client/server application. Therefore, as two access methods are being used to access the same data, I suggest two application software suites would need to be developed.

Remote databases need to be investigated. A key element affecting the viability of remote databases is the size of the result set. Sensible Design of the database may help in assuring that most request can be serviced locally, for example, a patient database for a hospital with it’s own region patients. In this situation, each hospital would maintain its own catchment area database, although the structure would be similar. Assuming suitable communications channels are in place, this scenario would allow day to day processing to take place. However, managerial applications may be developed which interrogate all regional databases, drawing the big picture.

The client/server model could support such regional applications although they require an application of considerable design. It is essential that any proposed system is thoroughly evaluated before a decision is made as there may be limitations to the proposed system. I suggest that you centralise data if you have to and localise data if you can.
Protocols and Standards

One great promise of information technology for the 1990's is the introduction of worldwide communications networks that will provide information exchange among heterogeneous computer and communication products and systems. There are many solutions which are very much short term solutions, proprietary by nature and tend to be more costly. Proprietary solutions may well solve the initial problem, but are very limiting when requirements arise later to integrate another operating system or another vendor's host.

The are only two internetworking standards, they are the Open Systems Interconnection (OSI) effort by ISO and the Internet Protocol (TCP/IP). At this stage, the term Protocol needs to be defined:-

Protocols are the set of rules that govern how packets containing data and control information will be assembled at a source workstation for their transmission across the network and then disassembled when they reach the destination workstation/mainframe.

ISO/OSI

The International Organisation for Standardisation (ISO) in conjunction with the Consultative Committee on International Telegraphy and Telephony (CCITT) developed a layered set of protocols known as the Open Systems Interconnect (OSI) reference model to facilitate communications between computer networks. One of the major goals of the OSI model is that in the future, it will be relatively easy for computers using OSI compliant hardware and software to exchange information regardless of the fact that they were manufactured by different vendors. The expanding work that is being done on OSI standards profile development, and testing indicates the accelerating drive, worldwide, toward the development of real OSI products.

The basic Reference Model for OSI sets out the framework with seven layers designated as follows:

Layer 1: Physical (wire)
Layer 2: Data Link
Layer 3: Network
Layer 4: Transport
Layer 5: Session
Layer 6: Presentation
Layer 7: Application
The functions of these can be summarised as follows:-

**Physical Layer**
It provides for mechanical, functional and procedural characteristics needed to access the physical links.

**Data Link Layer**
It provides functional and procedural characteristics needed to transfer data between points in the network and to detect (and possibly correct) errors occurring in the physical layer (e.g.; synchronization, error control and flow control functions).

**Network Layer**
It hides from the layer above (Transport Layer) all the peculiarities of the transfer medium i.e.; the data transfer technology and relaying and routing considerations) and provides relaying and routing through as many networks as necessary while maintaining the quality of service parameters set by the Transport Layer.

**Transport Layer**
It provides transparent transfer of data between end systems; hiding from upper layers the considerations of reliable and cost effective data transfer. It is concerned only with the quality of service. It optimises use of network services and provides additional reliability over that supplied by the Network Service.

**Session Layer**
It organises and structures interactions between application processes.

**Presentation Layer**
It allows the application processes to agree the rules of encoding for data transfer.

**Application Layer**
It is concerned with semantics of the application and does not provide services to any other layer.

There are few if any companies running a full implementation of an OSI protocol stack. Some companies run a partially implemented OSI stack in tandem with TCP/IP and will eventually drop TCP/IP altogether as OSI is fleshed out.
GOSIP

Government OSI Profile is a mandatory requirement for networking in Government Departments in the United States. GOSIP is a subset of the OSI model protocols as seen below:

<table>
<thead>
<tr>
<th>Layer</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application Layer</td>
<td>FTAM</td>
</tr>
<tr>
<td></td>
<td>MHS X400</td>
</tr>
<tr>
<td>Presentation Layer</td>
<td>CONNECTION ORIENTED PRESENTATION PROTOCOL</td>
</tr>
<tr>
<td>Session Layer</td>
<td>CONNECTION-ORIENTED SESSION PROTOCOL</td>
</tr>
<tr>
<td>Transport Layer</td>
<td>CONNECTION-ORIENTED TRANSPORT CLASS 4</td>
</tr>
<tr>
<td>Network Layer</td>
<td>CONNECTIONLESS NETWORK PROTOCOL</td>
</tr>
<tr>
<td></td>
<td>X-25 PACKET LAYER PROTOCOL</td>
</tr>
<tr>
<td>Data-Link Layer</td>
<td>X-25 PACKET LAYER PROTOCOL HDLC LLC</td>
</tr>
<tr>
<td>Physical Layer</td>
<td>IEEE 802.3 BASEBAND/BROADBAND/10 BASE T</td>
</tr>
<tr>
<td></td>
<td>IEEE 802.4 BROADBAND</td>
</tr>
<tr>
<td></td>
<td>IEEE 802.5 SHIELDED TWISTED PAIR</td>
</tr>
</tbody>
</table>

GOSIP is implemented in three different versions:

1. allows you to use electronic mail services and file management services. In addition, it uses Logical Link Control protocols for the bus, token bus, and token ring networks. It also includes the X-25 packet layer protocol, which means that both local area networks will communicate together. Note also that connection oriented service at the Transport Layer and connectionless services are also provided.

2. The next version is expected to add Office Document Architecture (ODA).

3. The third version is expected to add X-500 global directory services.

Even though the US Government Departments have implemented GOSIP, TCP/IP is still being used because of performance reasons and it's flexibility.

[12]
TCP/IP

As work on OSI proceeded over the last decade, the Internet Protocol emerged from the United States military networking environment as a functional, de facto set of standards for network communications.

The Internet Protocol, commonly known as TCP/IP, is actually a suite of protocols with TCP and IP the best known of the suite. The TCP/IP protocols are a layered set of protocols. Some of the protocols, including IP, TCP, and UDP provide low-level functions needed for many applications. Others are protocols for doing specific tasks.

TCP/IP is a high level protocol that is independent of the Data Link Level (e.g. Ethernet) and the Physical Layers (co-axial cable). A wide range of data link protocols exists. The interface between IP at the Network Layer (Layer 3) and the Datalink Layer protocol usually needs some help to perform certain functions. For instance, Subnetwork Dependent Convergence Protocol (SNDCP) is designed to translate between IP and datalink addresses (e.g. ethernet addresses).

TCP/IP is built on connectionless technology. Information is transferred as a sequence of datagrams. A datagram is a collection of data that is sent as a single unit. Datagrams are sent through the network individually. TCP/IP is designed for a LAN or extended LAN situation, however, serial connections are supported using the SLIP protocol. In some situations, this is suitable but is dependant on the application and the performance level required. The following diagram shows the TCP/IP network layers and how a typical TCP/IP configuration relates to the ISO/OSI model.
Terminology

IP

The Internet Protocol serves as the router for the datagrams (or packets). This protocol concerns itself with such as fragmentation of datagrams and internet addressing. Because different networks vary in the size of their packets, datagrams might have to be fragmented so they do not exceed maximum packet size. The IP provides the control information necessary to reassemble the fragmented datagrams.

A second major task of the Internet Protocol is internet and global addressing. Three different types of addressing schemes are available depending on the size of the network to which the datagram will be routed. They are as follows:

*Class A Addresses*
Each class A address can support 126 logical networks with nearly 17 million hosts on each network segment.

*Class B Addresses*
Class B addresses support 16,384 logical networks, with up to 16,382 hosts per network.

*Class C addresses*
Class C Addresses support up to 2,097,151 networks with up to 126 hosts on each logical network.

*Subnetworks*
It is possible to specify a subnet mask i.e. part of the host field will be used to identify subnets within the single network.

*Names*
TCP/IP networks can give each host on the network a name, a technique known as name aliasing. It is possible to access a host by using its name rather than its internet address.

Internet Control Message Protocol

IP relies on the ICMP for routing, error detection and other minor network management tasks. ICMP can alert IP when a packet cannot reach its destination, when a router does not have buffering capability to forward a packet, or when a network can send traffic on a shorter route. Formally ICMP is part of IP, but ICMP information is coded as if it were a transport protocol above IP.
ARP and RARP

For most LAN's, two other protocols, the Address Resolution Protocol (ARP) and the Reverse Address Resolution Protocol (RARP), operate at the IP level. These are SNDCP's for local area networking. Together these protocols solve the problem of relating Ethernet addresses and Internet addresses.

The ARP request is the method the network layer obtains the Ethernet address of a packet whose Internet address can be found. It usually is sent as an Ethernet broadcast packet. After receiving an Ethernet address, the ARP module stores the address in a cache. The next time the network needs that address, it will find it in the cache (where it always looks before it broadcasts an ARP request).

A RARP request is used during system initialisation when the sending host knows its Ethernet address, but not its own Internet address. RARP does this by broadcasting a "who am I" message at start-up, using its Ethernet address as an identifier. Usually, a RARP server answers the request and maps the Ethernet address to an IP network and node number.

TCP

Transmission Control Protocol corresponds roughly to the OSI's transport layer, but it also contains some Session Layer functions. TCP is responsible for establishing a session between two user processes on the network. It also is responsible for error recovery. It is primarily responsible for encapsulating information into a datagram structure, transmitting the datagrams, and keeping track of their progress. It handles the retransmission of lost datagrams and ensures reliability. Finally, on the destination computer receiving a message, TCP extracts the message from the datagram structure and forwards it on to the destination application program.

User Datagram Protocol

UDP also roughly operates at the Transport Layer as a client of IP. This protocol sends data but unlike TCP it does not perform retransmissions. It does not permit an optional checksum, so that corrupted data can be detected.

When a host running an application that uses UDP receives data, the data is sent from the IP layer to the UDP layer. Then, the UDP forwards the data on to the UDP data. Like TCP, UDP resolves datagrams to processes, within hosts.

Since UDP does not enforce reliability, it does not provide a sender with any indication that a datagram has been successfully received or the sequence they were sent. In some cases applications can perform without having a reliable Transport Layer.
STANDARD UTILITIES

Above the TCP/IP transport layer, direct parallels to the OSI model do not apply. The protocols that operate above TCP are not distinctly defined in an OSI Application, Presentation, or Session layer. These protocols are termed as user-level as this is the layer of the TCP network that the users see.

Telnet
Telnet consists of two parts:

1. On the workstation we must have a terminal Emulator capable of emulating the chosen terminal that attempts to talk to the chosen host using the Telnet protocol.

2. On the host we must have a terminal server program supporting Telnet-based hosts.

Telnet allows machines to act as workstations to TCP/IP based multi-user hosts. In a LAN / Extended LAN scenario RS-232/v24 connections are eliminated. The terminal software will emulate most well known terminals (vt100, vt220, ibm3270, etc.) often allow multiple sessions to co-exist concurrently, allowing a single PC to act as multiple terminals to the one host, or indeed connected to several hosts at once.

Telnet Emulators support multiple concurrent sessions either to the same host or to different hosts or to different hosts, and many allow you to return to DOS. Some Telnet versions can run in a Windows environment.

FTP

TCP/IP hosts should support FTP to allow file transfer between themselves and other hosts. Although somewhat rudimentary, FTP does provide an almost universal way to transfer files between dissimilar hosts on the same network.

SMTP- Simple Mail Transfer Protocol

SMTP is an E-mail protocol which uses a TCP virtual circuit to transmit and relay mail. The user interface is somewhat rudimentary but effective. SMTP is address oriented, rather than route-oriented so you do not need to specify a particular path to the receiver. You do, however, have the option of specifying a specific path. When a message is sent to multiple recipients on the same host, SMTP combines the addresses and sends only one copy of the message. This combination process greatly reduces the total bandwidth required in the network.
DNS - Domain Name Services

It is necessary to map names used by humans into addresses used by computers. This can be done by holding a simple table on each host. However if one workstation is added, all tables must be updated. On a big network, it becomes difficult to keep it up-to-date on every host. The DNS deals with this problem. Only some hosts store actual files of names and addresses, and they store partial copies. A specialised database query system directs its queries until it finds the correct copy.

NFS - Network File Systems

NFS was developed by Sun Microsystems and is an optional extra with TCP/IP (i.e., it costs!). NFS offers direct access to remote filing systems. As an additional layer on top of the TCP/IP network, SUN introduced the concept of the Network Filing System (NFS), a technique for describing how to access filing systems in a manner independent of the host machine or operating system. To the PC user, the remote filing systems appear as extra DOS drives - in this environment ordinary DOS commands can be used to keep and transfer files between Unix, VMS and Mac based hosts. Performance of this service needs to be carefully considered.
Transition from TCP/IP to ISO/OSI

The main incentive for the transition to the OSI protocols is the promise of greater functionality for the end user. It is expected that the robustness and stability that is included in the current TCP/IP specifications will not be available with early implementation of the OSI protocols. Technically TCP/IP has its limits. In particular there have been problems with its limited Global address space. It was never designed for use on networks with millions of nodes and the mail system is text only and was not intended to cover all corporate needs. Many of these problems have been dealt with by the IAB over the years but it has still been impossible to halt the inevitable push towards OSI.

During the transition from TCP/IP to OSI, there will be a major need to allow the existence of both protocol suites in the same networks. The main reason for this is that it is quite difficult to predict when all OSI protocols will be supported on all computer platforms within a single network and therefore must be able to provide an environment where both protocol suites are supported. In addition, some of the older computers will never support OSI protocols. The evolution of networks with heterogeneous computer hardware and operating systems can be viewed as a progression through four distinct phases.

Phase One

The low level communication provided by TCP/IP and user-level functions provides by the TCP/IP applications such as TELNET, FTP and mail. Users are provided with stable, low-level communication protocols which are mature and reliable with no frills attached user-level applications.

Phase Two

The gradual shift to OSI will be driven by user requests and product availability. The ability to run the OSI applications over TCP/IP lower-layer protocols is possible by using the protocol defined in RFC1006 which allows a switch to TCP at the Transport Layer.

Phase Three

As the transition to the use of the lower-level OSI services begins, there will be a need to provide connectivity to the existing TCP/IP networks since some computer systems will no longer support the TCP/IP protocols. There are some approaches to maintain this connectivity.
Application Gateways will be required in situations where older computers that will never support the OSI protocols are connected to the network. It will enable users of these computers to communicate with the new OSI computing resources via TCP/IP protocols. It must be recognised at this point that application gateways have limitations:

1. Performance Limitations. Since an application gateway requires the support of all the layers below, both complete protocol stacks (TCP/IP and OSI) must be used.

2. Functionality Limitations. Users are limited to the use of features supported by both protocols which means the functionality of the TCP/IP applications.

Transport Service Bridges (TSB) are bridges between the two networks at the Transport Level. The TSB supports communication between OSI applications running over TCP/IP lower-layer protocols and OSI applications running over OSI lower layer protocols. Since the TSB relies upon the support of OSI applications in both environments and the connection is provided at the Transport Layer, both of the major problems are addressed.

Phase Five

The transition to OSI will occur when OSI protocols are available for use in all of the computing environments on a particular network.

Sites Visited

Guinness Ireland

Guinness Ireland have 14 Vaxes and 7 UNIX machines with over 200 Novell users. Ethernet is used as the backbone with fibre links to geographically dispersed locations. A need arose to integrate the various hardware platforms. They decided that TCP/IP offered them the only realistic method today. A workstation can now access any VAX or UNIX host as well as any Novell LAN on the network. In addition, any printer whether it be on a UNIX machine VAX host, or Novell Network can be accessed from any workstation on the network. Guinness's have some remote sites that have their own local computing. Central computing and local computing is shared using the extended LAN technology. From Guinness's experience, to implement and support TCP/IP a high level of knowledge is needed of TCP/IP, local area networks, and the different computer platforms.
Department of Labour

The Dept of Labour is made up of a sizeable Novell network with multiple Novell servers and high performance PC servers using SCO UNIX. In addition, they have a VAX which they will eventually phase out as they move their applications to the PC and UNIX platform. They have a client server application using Oracle on a SCO UNIX platform. TCP/IP is solely used as the transport mechanism for this Client/Server application. CCmail is used as their electronic mail package with an X-400 gateway to the other civil service departments. It must be noted that all applications are running in an Ethernet LAN environment.

Department of Environment

One of their relational database applications running on a microvax 3100 was changed to client/server architecture. They use an Ingres Database engine and Wollongong TCP/IP was recommended as the transport mechanism. At the time, Wollongong TCP/IP was the only TCP/IP certified by Ingres. In addition, they have a number of Novell Netware Networks. Again, Client/Server Application is accessed from the local environment only.

Note:- In all the above cases TCP/IP co-exists with Novell's IPX. i.e. Concurrent sessions to the different platforms is possible.
Network Management

It is absolutely critical that there is some way to monitor, manage and control traffic over the network. Two network management protocols that need to be looked at are SNMP associated with TCP/IP and CMIP associated with OSI networks.

SNMP

Designed originally as the network management protocol for TCP/IP, this protocol is now able to monitor network traffic and to indicate malfunctioning equipment and performance bottlenecks on a variety of non TCP/IP network devices including 802.1 bridges. SNMP was developed as a connectionless protocol to reduce overhead requirements and to maintain control on the part of the user rather than have parameters handled transparently as they would be in a connection-oriented protocol.

SNMP protocol links a network management system and a device that is being managed. The device contains an agent that communicates with the NMS. Information is stored in a Management Information Base (MIB) containing network structures. Because the MIB is defined in standard terms for managing an internet router, vendors must extend the MIB so that information will be relevant for their particular device. In SNMP, "you ask for just want you want, and what you asked for is just what you get". SNMP works by polling, or regularly asking each device for its status.

CMIP

Common Management Information Protocol (CMIP) is a draft standard for network management over OSI networks. CMIP offers a much more robust set of tools for network management than SNMP. CMIP uses classes, objects and attributes. An object might be a device while an attribute might be that device's condition or parameter describing it.

CMIP uses reporting or having the device inform the manager of its status when it changes. CMIP is generally thought of as having more specific features and capabilities but the question is whether these capabilities are what you really want or need. SNMP tends to be smaller, faster and less expensive than a CMIP implementation.

CMIP has not really taken off because of the small base of installed OSI networks. Because of this, Common Management Over TCP/IP (CMOT) protocol consists of standard CMIP with a Presentation Layer that maps OSI layers 6 and below to TCP/IP.

[21]
The data services offered by Telecom can be shown in a hierarchy.

MAN
Dassnet
ISDN
Eirpac
PSTN

The PSTN signifying low cost and limited performance stands at the end of the list. At the high end of the new hierarchy is the MAN. This broadband network will accommodate operations that need high bandwidth on demand.

Most requirements over the next few years will fall in the middle ranks of the Telecom network hierarchy i.e. the packet switched data service Eirpac, the new ISDN and Dassnet for delivering leased lines. Also to be included will be a Frame Relay service which Telecom hopes to offer in the future.

It is expected that a tariff restructuring will take place. It is expected that Dassnet and analog leased lines tariff will increase. Leased lines will be considered as premium products for organisations whose communications needs cannot be met by frame relay or ISDN. The need to build private networks will still remain if management control and security are important issues and if there is a strong economic justification. I will have a better picture when the new services are introduced and the tariff restructuring is made public. The two new services are discussed as follows:

ISDN

Integrated Services Digital Network (ISDN) is an evolving set of international standards for connecting voice, data, and video equipment. With ISDN, a user will be able to carry on a voice call while simultaneously viewing video images or retrieving information from a computer. With ISDN or more precisely Narrow Band ISDN (NB-ISDN) there will be two user accesses:

Basic Rate Access

The basic rate access is a 192 kbps digital access provided on ordinary local loop cable pairs. It comprises of two 64 kbps bearer channels called B channels, which are used for circuit-switched voice and non-voice services, and one 16 kbps signalling channel called the D channel. Typically, basic access will be provided by upgrading an existing ordinary telephone line to ISDN standard.
Primary Rate Access

The primary rate access is a standard 2048 kbps digital link that will probably be provided on optical fibre for multiplexed access configurations and on screened pairs for single-link access. It comprises of 30 B channels and one 64 kbps D channel. The D channel may be replaced by an "E" channel in primary rate multiplexed access configurations. The "E" channel is also a 64 kbps signalling channel, but does not use the same signalling protocols as the D channel. Primary rate would typically be connected to a suitable PABX.

The ISDN signalling systems are modelled on the OSI reference model. The correspondence is far from exact and many of the ISDN protocols are unrelated to the OSI protocols found in the same layer. Like its OSI counterpart, the ISDN physical layer deals with mechanical, electrical, functional and procedural aspects of the interface.

ISDN uses the out of band signalling concept. In basic rate access, the full 64 kbps on each B channel can be regarded as pure user data, with no required header or other overhead. ISDN does not specify the contents of the B channels i.e. you can format the channel into frames in any way.

The situation of the D channel is used to communicate with the ISDN system itself. The format and contents of packets transferred on the D channel are specified by CCITT SS # 7. It is referred to as out-of-band signalling. The D channel under ISDN uses the I.450/I.451 protocols at the Network Layer to recognise the type of packet as well as the type of message being transmitted. This layer covers the establishment, maintenance and termination of calls through the network.

ISDN will open new opportunities for transmitting data flexibly and effectively. It will be designed as a circuit switched telecommunications network and transmission paths will be routed through ISDN exchanges. This means they will not be permanent and the time required to set up an ISDN switched connection will basically depend on the number of exchanges involved, averaging about one second to set up a call.

On the data front the EHB can use ISDN for backing up existing digital leased lines. In addition, it may be advantageous to link remote workstations (via an ISDN network interface card) to central databases. Client/Server access may be provided from remote sites by using this service. It must be noted that higher level protocols such as DECnet, TCP/IP, X-25 etc. can be run over ISDN.

Telecom Eireann have not delivered ISDN as of yet but it is expected to be delivered in late 1993 to certain areas. Tariffs for ISDN services have yet to be made available but will be on a usage basis and may be similar to the X-25 tariff.

In the future, ISDN called Broadband ISDN (B-ISDN) will raise the bandwidth threshold to over 600 mbps and could provide the bandwidth necessary for large scale transfer of high-resolution video along with voice and data information. B-ISDN is not available now but should be available in the next 3 to 5 years.

[23]
Metropolitan Area Network.

In between a LAN and a WAN lies the metropolitan area network (MAN), a network that covers an entire city. The IEEE 802.6 Committee has developed recommendations for a MAN that incorporate the concept of dual counter-rotating rings or buses similar to FDDI. MAN's are designed to act as digital backbones that link together LANs throughout the city. They are designed to handle voice, video and data traffic at speeds in excess of 100mbps and can incorporate optic fiber, coaxial cable and even radio transmission as media.

The MAN is composed of dozens of subnetworks that communicate with each other through bridges, routers or gateways. The "glue" that makes all this work is a protocol known as distributed queue dual bus (DQDB). DQDB consists of a dual bus topology with traffic travelling in opposite directions. An access unit (AU) attaches a network workstation to the dual bus cabling. The AU contains the protocol necessary to perform DQDB functions. Malfunctioning AUs are ignored by the network.

Nodes use a "QA slot", a packet that includes a header and a data field. Two key fields in this packet include a busy bit, which indicates whether or not a slot is empty and a request field, which indicates whether the slot is being queued for transmission.

Nodes set bits on QA slots travelling on one bus to reserve a slot travelling on the other bus. Nodes maintain a counter that tells them how many requests are pending in a queue; hence, they know how many empty slots a node must ignore before it becomes its turn to access the slot. The advantage of this type of approach is that the slot is constantly in use; there are always nodes with reservations waiting their turn.

Telecom Eireann have implemented a DQDB running initially at 140 Mbits with an eventual upgrade to 622 mbits. The MAN should be a cost efficient system, but the shared access functionality limits to which it is suited. Essentially, the broadband network will be best for tasks that involve sporadic traffic bursts and very high peak data rates. Frequently quoted examples are medical imaging between hospitals and consultants, electronic pre-print operations for newspapers, remote storage and retrieval from document images or photographic databases and many multimedia applications. There will be some spurs to certain locations in the suburbs. Customer access rates will be 2 Mbps up to 34 Mbps. Lan standards such as IEEE 802.3 and IEEE 802.5 are supported as well as FDDI and in the future Frame Relay.
X-25

X-25 is widely used at the connection-oriented network layer protocol of the OSI model. X-25 defines the interface between the host called a DTE (Data Terminal Equipment) and the carrier's equipment called a DCE (Data Carrier Equipment) and the switch as the PSE (Packet Switching Exchange).

X-25 layer 1 deals with the electrical, mechanical, procedural and functional interface between the DTE and DCE, X-25 does not define these things but references two other standards X-21 and X-21bis which defines the digital and analog interfaces respectively. X-21bis is an interim standard to be used on analog networks until digital networks become widely available.

The job of layer 2 is to ensure reliable communication between the DTE and the DCE, even though they may be connected by a noisy telephone. The protocols used are LAP and LAPB. CCITT adopted HDLC (High Level Data-link Control) for its LAP (Link Access Procedure) as part of the X-25 network interface standard but later modified it again to LAPB to make it more compatible with a later version of HDLC. These protocols are bit oriented and all use bit stuffing.

Layer 3 manages connections between a pair of DTEs. Two forms of connections are provided. The association between two DTEs may either be a permanent one (a "permanent virtual circuit") or a temporary one (a "switched virtual circuit"). The only important difference between these two types of virtual circuits is that the switched virtual circuit requires that when a DTE wants to communicate with another DTE, it must first set up a connection. The DTE builds a Call Request packet and passes it to its DCE, which then gives it to the destination DTE. If the destination DTE wishes to accept the connection, it will send a Call Accepted packet back. This is forwarded to the calling station as a Call Connected packet (assuming there is no network congestion). Data transfer can then take place. At the conclusion of data transfer, either station can cause the connections to be taken down by sending a Clear Request packet into the network. The network also sends a Clear Indication packet to the other station and that in turn responds with a Clear Confirmation packet. At this point both DTEs may use the full duplex connection to exchange data packets. A virtual circuit number is chosen to identify the connection.

As can be seen from above, there is a cost involved in setting up the connection, however, when the connection is made the data transfer is more efficient than the connection-less type network as packet sizes are more efficient plus source and destination addresses are no longer required in point to point situations.

With packet-switching networks like X-25, buffers can be reserved in advance to ease congestion, sequencing can be guaranteed, short headers can be used and the troubles caused by delayed duplicate packets can be avoided. With the datagram approach, there is more potential for congestion but also more potential for adapting to gateway failures. However longer headers are needed.

Comparisons can be made between X-25 network equipment and the DCA equipment in that it is circuit switched. However DCA multiplexing cannot avail of high bandwidth.

[25]
Sites that use X-25 are as follows:

**CIE**

Similar to EHB, CIE is a pure DEC Site with host computing centralised in Dublin. Sites throughout Ireland access this computing resource. Originally, CIE used Timeplex Statistical Multiplexing but have migrated to an X-25 network. CIE see that their computing will remain centralised host based computing with dumb terminal access.

X-25 was chosen because it was felt that it was best suited to take advantage of higher bandwidth than Timeplex Equipment. CIE do not use ethernet as they saw it as being an eventual bottleneck to their centralised computing. In addition, it was seen that there was better evolutionary path with an X-25 network for future computing use.

**AIB**

AIB have an Northern Telecom X-25 network. Each branch is serviced by this network. The branch network is very much dumb terminal based. X-25 offers reliability of service and a growth path to future needs for higher bandwidths.
Frame Relay

Frame relay is a transparent network access protocol for high speed LAN switching over WANs. Born out of CCITT’s standardisation work on ISDN, it uses a subset of the Link Access Protocol-D (LAPD) standards to provide statistical multiplexing at speeds of up to 2.048 Mbps. It is a packet mode bearer service operating entirely within the Data Link Layer of the OSI reference model. This simplification of network access gives frame relay its speed.

In the past, if you wanted to connect LANs over a wide area, you had two main options: point to point connections and packet-switched networks, usually in the form of X-25 public and private data networks. Neither option offers sufficient throughput for transparent LAN to LAN connections.

Frame relay is an adaptation of a packet switching technology developed for ISDN. As such, it is usually thought of as a replacement for X-25, although in practice frame relay may be overkill for the types of low-bandwidth applications where X-25 excels. Its ability to connect geographically distant LANs at high transmission speeds and to allocate bandwidth as needed.

X-25 has never been a satisfactory method of internetworking LANs. The protocol normally limits transmission speeds to the packet assembler/dissembler to 56,000 or 64,000 pps, and its extensive error checking slows throughput considerably. Trials have shown that frame relay technology has up to 10 times the throughput of X-25. The other alternative is to create point to point links using bridges, routers or multiplexors.

Because digital transmission is much more reliable than older analog technologies, frame relay requires far less robust error checking than does X-25. It checks packets only where they enter and leave the frame relay network. Thus frame relay networks can assemble route and disassemble packets much faster than X-25 networks can. If a packet or frame of data is lost in transmission it is up to the system receiving the data to request it back. This is where frame relay could hook into higher level protocols such as TCP/IP that could provide the error detection and correction etc.

The Frame Relay standard does not describe how to switch packets, but it defines how the interface equipment presents them to the frame relay network using a LAN bridge, router or T1 multiplexor equipped with a frame relay interface. Frame Relay’s ability to handle bursts of traffic and high speed connections make it ideal for interconnecting LANs. Like X-25, frame relay provides virtual circuits between sites, resulting in less overhead.

Frame Relay exists today only in draft standards. Because the internetworking problem is so acute and the standards-setting process is so time consuming, many companies have jumped into the frame relay market with products based on draft standard. Frame Relay is in its infancy now, but it will be a prime internetworking technology. Telecom Eireann in the future will introduce a public Frame Relay service but private Frame Relay networks may also be developed in the future.
Mobile Data Communications

In respect to data communications, it is expected that wireless communications in the coming decade will be as commonplace as wired data communications is today.

Two forces are at work to make wireless data communications one of the most important technologies of the future:

1. With every improvement in integration, miniaturisation and battery technology, the difference between the performance of desktop computers and portables shrinks, as does the premium you pay for portability.

2. The desire for universal connectivity - Normally, the forces of portability and connectivity are at odds, but wireless data communications lets you have the best of both worlds i.e. freedom from the desktop and connectivity.

Despite the narrow focus of current wireless applications, there is now a new drive within the Industry to cater for general computer users with services such as E-mail, access to standard information services and support for remote sessions on host computers.

When this technology is available in Ireland, it could offer many benefits to the EHB. It could be used by the EHB professionals in the community e.g. Environmental Health Officers, Public Health Nurses, Community Welfare Officers etc. Some of the benefits it could offer are as follows:

- **Reduced Paperwork** - Field notes are inputted once and in real time from the field.

- **More efficient Scheduling** - Schedules can be changed and communicated to the professional in the community.

- **Accommodation Savings & Better productivity** - The professional spends more time in the community, thus reducing the need for office space. More time in the community and less time in the office should mean more calls being met i.e. better productivity.

- **Contact ability** - Community Professionals are able to be contacted at all times of the day from any office in the EHB and vice versa.
Present EHB Applications To Be Considered

Psymon System

The Psymon System is a PC based system designed with a Local Area Network in mind. However, it does use a technique called pcANYWHERE to port it to the wide area sites. It allows remote workstations to communicate to the central server over serial lines. In effect the remote workstation is acting as a terminal with the Central Server and its multiprocessor boards driving data and graphics (screens and colour) down the communications channel. For effective use speeds of 9600 bps is recommended. It is proposed to implement the system in 27 sectors with each sector containing a number sites. The majority of sites are small and are presently not networked.

The Psymon System has major implications in networking of new sites as well as on current networked sites. With the new sites, leased lines would be a requirement. In some cases dial-in access might be more suitable especially for sites that use the system for short times and on an irregular basis. Adding one or two workstations to a site that is currently networked will cause a major degradation in performance with current systems accessed. The degradation will be directly related to the number of Psymon workstations and the amount of online activity experienced.

Another point is that proposed Psymon sites will effect other sites that are routed through common dataswitches. An upgrade in communications lines to Dr Steeven’s Hospital would be essential. Another point is that the type of access method for Psymon system is different from the access method required by the the proposed Social Welfare System i.e. two different access methods will be required from small Health Centre sites.

A few factors that may aid Psymon’s implementation:-

1. Client/Server Architecture - this may help the performance of the system over the wide area.
2. ISDN - When ISDN becomes available it may be used by a remote workstation at speeds of 64KBPS.
3. The proposed system has been discussed in respect of a central server in Dr Steeven’s Hospital. The idea of having local servers serving catchment areas may be more efficient.
Psymon system needs to be looked at very carefully in relation to the equipment needed, the access methods required and the costs involved. Because of the nature of the Psychiatric Service, a major investment will have to be undertaken if Psymon is to be fully implemented. From a cost point of view a host based system may well be more efficient and realistic at this course in time.

**Finman System**

To date the Finman System has been implemented in CCA7 and is being implemented in Cherry Orchard campus. The system is host based based and is centralised at Dr Steeven's HQ. However CA (Computer Associates) are soon to introduce a client/server version of this system. The EHB may wish to avail of this in the coming years.

Presently, Finman is accessed via VT420 terminals and because of the nature of the system, there is a lot of screen painting. Current bandwidth and capacity at the sites where Finman is being implemented need to be looked at.

I suggest that each site needs to be looked at individually as there are different solutions depending on the size and profile of the site. For instance, sites that will only have dumb terminals a 64kbps packet switching multiplexor could be used for a big site while a statistical multiplexor may be used at a small site. A Bridge/router could be used in a site that have or will have a need for dumb terminals, client/server applications, local processing and PC LAN interconnectivity.

**Cyborg System**

This personnel system will be introduced quite shortly to EHB sites. Again it is a host based system, centralised at Dr. Steeven's Hospital. At this stage it does not show any special networking needs and the same evaluation followed for Finman sites should be continued.

**D.S.W. System - Common Means Database**

The Department of Social Welfare will be introducing the Common Means Database as a new integrated service in 1994. It is envisaged that Community Welfare Officers in the EHB will have access to this proposed system. This amounts to over 67 Health Centre sites in which only a minority is networked.
Dumb Terminal access of speed rates of 4800 bps would seem to be the initial requirement. Presently, this service can be provided by statistical multiplexing, however, with the advent of ISDN connectivity, this will need to be considered for future connectivity.

The Environmental Health System

This System will most likely be operating on a Vax VMS platform with dumb terminal access. The system will be implemented in five sites, Wicklow, Kildare, Gardiner Place, Capel Street and Dr. Steeven's Hospital. The initial requirement of dumb terminal access should be achieved with the current technology being used in the Board.

The Environmental Health Officers could benefit from Mobile Data Communications (when it is available in the future). These field workers would be able to communicate with their base vice versa. This opens opportunities for messaging, electronic mail and remote database access without these professionals having to return to their base.

The Social Worker System

The plan will be to bring this proposed system to 30 EHB sites which are made up of the 10 Community Care Areas and about 20 Health Centres. At present, the hardware and software platforms have not yet been decided. However, there is a possibility that the system will be served by a PC server at the central site and Workstations at the remote site. If this is the case, the system will have the same implications as the Psymon System. At present, there is no economical method of bringing the appropriate bandwidth to the remote sites. The availability of ISDN in the near future may well be the answer for this type of access. If a host based system is followed, the current multiplexing technology should be adequate.

Because the proposed system will serving remote sites, the hardware and software platform must be looked at together with communications method and access requirements in mind i.e. Communications Requirements are just as important as the Software and Hardware Requirements.
Conclusions

From a networking perspective, the EHB is quite difficult and complex due to the fact that the majority of EHB sites are small and dispersed. This trend is continuing with the decentralisation of the Psychiatric Services. The larger sites such as the General Hospitals and the medium sized sites such as the Community Care HQ's are in the minority. In addition, the EHB is made up of numerous and diverse professions with different work patterns and information needs. Future services such as ISDN and Mobile Data Communications may go some way in making information technology more accessible to these professionals and the smaller locations in the EHB.

The EHB networking to date has been to support dumb terminal access to mainly centralised host based applications. If the strategy of host based computing is to be continued, I believe that a network such as an X-25 network and/or statistical multiplexing scenario would be the best strategy to follow. However, I believe that the EHB will want to avail of more functional systems and new technology in the not too distant future.

Therefore, a network that will support current access methods and future applications needs to be grown. The network will have to support traditional dumb terminal access, LAN interconnectivity, client/server architecture, multi-vendor computing, multimedia applications, corporate e-mail and e-mail connectivity outside the EHB.

The following are my findings:

Client/Server Computing

Client/Server computing cannot be ignored as it adds better functionality and takes in PC processing into the EHB computing framework in a cohesive manner. To date, I have only witnessed client/server computing operating in a LAN based environment, but I believe it can be taken to the wide area with a supportable infrastructure and adequate bandwidth. A few important points need to be remembered:

1. Not all applications are suited to a client/server architecture and therefore applications need to be carefully looked at to ascertain suitability for this architecture.

2. Even if the application is suitable for client/server, the success of the system will be dependant on how efficiently it is written e.g. the amount of calls it has to make to the database and how the database is designed.

3. Client/server over the wide area needs adequate bandwidth. Dassnet Circuits (64 kbps to 2 megabits) or ISDN connections will be required depending on the site profile.

4. EHB is geographically spread and consists of some large sites but many small sites. In most cases Dassnet lines or even analog leased lines may not be justifiable. ISDN when it arrives to all EHB areas should be well placed in meeting these requirements. Presently, there is no cost effective way of providing client/server to the small sites.
5. Sensible regionalisation of data in client/server computing as well as host based computing would be an optimum solution. This would offer better performance to the user, be less dependant on one central site i.e. "fire-walling", and localise data thus reducing excessive traffic to the Central Site.

6. The normal growth path to client/server is usually from a relational database application which then is converted to client/server architecture. This is due to the DBMS occupying alot of memory and it's monopolising effect on the CPU. The choice is either to upgrade the hardware or follow the client/server route.

E-MAIL

An E-Mail service needs to be considered for the EHB as it offers many benefits. For instance, community care professionals in one area could communicate documents, messages etc by electronic means to another area. Dial-in modems could also be used for home access.

A further investigation should be carried out to choose the appropriate E-mail system for the Board. The system should cater for inter-communications messaging between Vax terminal users, PC workstations and Apple MAC workstations. The system chosen should encompass an X-400 gateway and should be an integrated system with multiplatform internetworking requirements in mind.

In addition, external mail is of major importance and must be investigated. There seems to be a growing need for the EHB to be electronically capable to communicate with the outside world and vice versa.

Protocols

I believe that EHB will continue to work in a multi-protocol environment and the network should be able to support this. For instance, proprietary protocols such as Novell's SPX/IPX and DEC's LAT are very much suited to the LAN environment while Frame Relay is much suited as a transport mechanism over the wide area.

However, some protocols give added functionality and flexibility especially in a multi-vendor environment and a client-server environment. The TCP/IP suite being the de facto internetworking standard is the only mature protocol presently available that meets this description. However, our long term aim should be towards OSI equipment and protocols when mature and affordable products become available. Most TCP/IP implementations give a migration path to OSI.
Presently, no advantage will accrue from investing in TCP/IP. It will only become necessary if:

1. UNIX access and VAX is needed by the same PC users. Existing dumb terminal users can be accommodated by a TCP/IP handler on the DCA network while current terminal servers in Dr Steeven's support TCP/IP.

2. The client/server applications needs TCP/IP as their transport protocol. The relational database and hardware platform decided upon will determine the protocol that should be used. TCP/IP is generally supported by most relational database vendors. However, some will only support certain versions of TCP/IP.

Telecom Services

To date we have used Dassnet and Analog leased line services from Telecom. However, new services will be offered in the not too distant future i.e. ISDN, MAN, Frame Relay. It is also expected that there will be a major restructuring in tariffs for all services. The EHB should choose the service that will suit the access and speed requirement of the particular site. We will avail of a combination of these services.

When ISDN is available, a pilot should be set up to see the kinds of benefits that can be gained from this service. The PSYMON System or the proposed DSW System may be suitable for this pilot.

Present Networking Equipment

Our current network consists mainly of DCA equipment serving the Wide area and more recently Bridge/Routing technology has been introduced to a few sites. DCA equipment is very robust and has served us well to date. It is very much suited to small to medium sites that need dumb terminal access only. One important feature of DCA dataswitches is that it can be linked to an ethernet network. However, as the statistical multiplexors were designed for analog speeds, they will not be capable of taking advantage of ISDN connectivity. I expect the need for more bandwidth will increase as new types of applications are desired in the EHB.

When bandwidth on demand is available from Telecom and more networking products are brought on the market, I believe that we should migrate from the DCA equipment. This should be seen as medium to long term strategy.
Bridging/Routing is well placed in meeting our networking needs especially in the big sites that need permanent connectivity for central computing services. The smaller sites (with some exceptions) should be serviced by ISDN connectivity and ISDN compatible equipment especially when client/server and PC connectivity is a requirement.

It defeats the purpose of installing Bridge/Router technology only to give dumb terminal access. There are other technologies like X-25 that are more equipped for this type of access. The Bridge/Router technology's main advantage is inter-LAN connectivity.

Also, I believe that if we continue following the extended LAN scenario for all EHB sites and keep placing all our computing at the Dr Steeven's Hub, that over time this will lead to traffic congestion at the Hub. Sensible regionalisation of certain applications may be very worthwhile.

Printer traffic should be treated as part of normal data traffic. Printing does have a bearing on performance as it utilises bandwidth for the duration of the print. Printing performance should be quantified for the particular site and the communications link should be sized accordingly.

The strategy of the Board should be to develop a flexible and dynamic data network that will be able to take advantage of current and future services. I believe that these recommendations should meet this aim and should carry us quite adequately into the new millenium.