VIRTUALISATION SOLUTION FOR A HEALTHCARE ORGANISATION

MSc Thesis in Computer Systems Management

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Academic Year: 2010 – 2011

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Date: August 18th, 2011

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ABSTRACT

Client-server computing is one of the oldest forms of networking where clients are PC's that can process and exchange information, store data and applications, upload and download important files. Servers are powerful PC's capable of storing back-ups of all the data and applications stored on each user's PC in case of a data disaster or PC failure. There are different types of servers like application server, database and storage server, mail server, FTP server, web servers and each type of server serves a particular purpose. But as technology advanced during the recent years, client-server computing began to lack in functionality, performance, reliability and security. Organisations using this network constantly faced security threats, overload on the server and network and poor performance. Organisations were also finding it difficult to cope up with the costs related to maintaining and upgrading their client-server network.

Thin-client computing technology emerged as a solution to the underlying limits of client-server network in which, server-based and desktop virtualisation is the widely used technologies in thin-client computing. Desktop virtualisation is the most powerful thin-client technology is as it gives its users a rich and full PC experience, allowing them to easily work with data without any hassle. Virtualisation has become an intelligent, highly secure, reliable, and cost-effective and centrally managed network for the many organisations using it. Virtualisation reduces the Total Cost of Ownership (TCO) to a great extent, improves services and lowers the power usage used by a traditional PC.

In healthcare, virtualisation has shown tremendous results. Many healthcare organisations have staffs who work outside their hospitals, clinics and other remote locations throughout the day. It has become a challenge for IT professionals to provide a highly secure, reliable and an efficient network to their staffs so that they can easily access medical applications and other confidential data.

This project focuses on deploying a virtualised thin-client network for a healthcare organisation. A study on the existing network will identify the different software and hardware used by the organisation, Operating Systems and problems being faced by the network. A virtualised thin-client network will then be designed and implemented which will help in delivering a highly secure, reliable, cost-effective and accessible network for the staffs, academic interns and remote staffs of the organisation.

ACKNOWLEDGEMENT

First of all, I would like to thank God for His blessings, support and giving me the confidence and willingness to move ahead successfully with this project.

I would like to thank my supervisor, Ms. Subashini Priya, for her valuable guidance received throughout this project. From the time I started with this project, it was her suggestions and feedbacks that made me successful enough to complete this project on time. And lastly, I would like to thank my loving family and friends for their support and encouragement.

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CHAPTER 1. INTRODUCTION

Information sharing is an important concept used in many organisations for transferring information between computers and the Internet (Fig 1 Information sharing in a computer network). Computers are the main source of elements used for exchanging information between users and in order to make this communication to take place; the computers must be connected to each other in some form. This is where computer networks come into place. A computer network is the solution by which computers can communicate with each other.

Technology is advancing in today's fast-paced and tech-savvy world especially in the field of networking where computers communicate with each other for information sharing. This kind of information sharing is necessary for organisations in order to go about with their daily business routines. Like other sectors, healthcare is one main sector focused on bringing new technology to the hospitals worldwide which will benefit them in terms of profit, cut down the IT costs thereby providing the best healthcare to their patients.

City HealthCare (CHC) Medical City (name changed) is one such healthcare organisation facing problems with their current network like slow connectivity, overload on the server, security threats like viruses, bandwidth utilisation and huge IT costs. One way to solve this problem is by bringing in a new technology i.e., *Thin Client Computing* which is a perfect network solution to the organisation. The idea of thin-client is simple: Instead of running all the applications on individual clients, run these applications centrally from a server and deliver the screen outputs and updates to the clients.

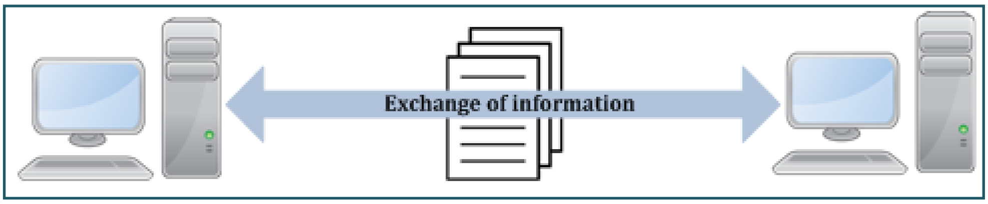

Fig 1 Information Sharing in a computer network.

1.1. AIM OF THE PROJECT

The aim of this project is to develop a high-scale network solution for a healthcare organisation by using virtualised thin-client technology. The network design will include utilising the current hardware and software being used and if required bring in new resources, thereby reducing network maintenance costs and at the same time providing a fast, secure and reliable and intelligent network to the organisation.

1.2. OBJECTIVES

The aim of this project can be achieved with the help of the following objectives:

- First, analyse and study the current network framework of the organisation, its limitations and how to overcome the limitations.
- Second, design and develop a complete LAN infrastructure for the organisation using virtualised thin-client computing.

1.3. PROJECT DESCRIPTION

The reason for doing this project is to design and implement a thin-client network for a healthcare organisation using desktop virtualisation; the latest and successful technology in thin-client computing. To make this project a success, a study of the different healthcare organisations based in the Middle East and their current network scenario was performed; of which one healthcare organisation was chosen as its network issues suited the aim and objectives of this project. The organisation on which this project will be done is CHC, a medical organisation comprising of a hospital, dental and family clinic and a research centre.

A study on the current network scenario of CHC is done and its limitations have been identified. Desktop virtualisation has been designed and implemented to overcome these limitations and give CHC a new virtualised networking environment. The design of the network involves considering the existing medical and non-medical applications, desktops, servers, hardware and networking components. These components are checked for compatibility of a thin-client network and the same components have been used avoiding the need to replace the entire network devices with new ones which will be very costly. Implementing the network is done in each division of CHC separately; careful planning and time is taken to implement the network in stages. The new network will eradicate the problems faced by the old network, reduce TCO and allow room for further network upgrades or expansions.

1.4. PROJECT REPORT OVERVIEW

CHAPTER 1

- *Aim and objective of doing this project.*
- *Brief description about the organisation, list of requirements, implications and limitations of the project.*

CHAPTER 2

- *Concept of networking, types of network, network components, how to design a network.*
- *Thin-client networking and types.*
- *Desktop virtualisation, virtualisation best practices, advantages and disadvantages.*
- *Success stories of thin-client computing in the healthcare sector*
- *Summary of chapter.*

CHAPTER 3

- *Current network status and design, network distribution, physical LAN diagrams, software and hardware being used, limitations of the existing network and how it can be solved with desktop virtualisation.*

CHAPTER 4

- *Requirements for implementing the network*

CHAPTER 5

- *Method and timeline required for implementing this project*

CHAPTER 6

- *Designing the virtualised network, new logical and physical LAN diagrams.*

CHAPTER 7

- *Implementing the network in stages*
- *Challenges faced.*

CHAPTER 8

- *Testing the network based on performance and security*
- *Possible risks identified, network evaluation*
- *Strengths and weaknesses of the new network*
- *Recommendation & future work*
- *Summary of chapter.*

CHAPTER 9

- *Professional, legal and ethical issues involved*

CHAPTER 10

- *Summary and conclusion of the project.*

1.5. ORGANISATION OVERVIEW

City Health Care or CHC is one of the largest medical organisations in the Middle East which consists of one main hospital, dental clinic, family clinic and a research centre. This organisation consists of Board of Directors, members of senior management, doctors, nurses, physicians, x-ray technicians, lab technicians, IT staffs, finance staffs, administration and marketing staffs, pharmacists and medical interns who work as trainees. There are also administrative or clerical staffs that look into the billing, payment, pharmacy, information services and other support services of CHC. Other than the IT departments, the various medical departments in the main hospital include Cardiology, Paediatrics, Radiology, Dentistry, Pathology and Laboratory Medicine, Psychiatry, Critical Care or ICU, Surgery and Rehabilitation. They have one dental clinic and family clinic which has General Practice, Gynaecology and Dentistry. They also have a Diabetes & Research Centre which was built last year to give treatments for diabetes patients. The organisation constantly looks into bringing in new technologies to their hospital and clinics in order to give their patients the best health care in the country.

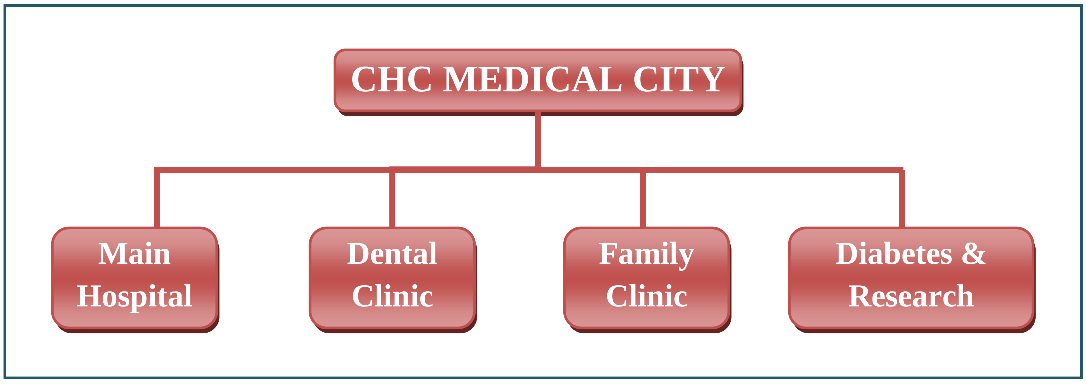

Fig 1.5 CHC Organisation Structure

1.6. LIST OF REQUIREMENTS

Currently the network being used at CHC is the client-server network where all the data and applications are stored on both client computers and servers. When a file or application needs to be accessed, the file needs to be uploaded to the client PC from the server; data processing takes place at the local PC. Any changes made to this file needs to be saved back to the central server. In addition to this, the users also need to save a local copy of their files they use regularly in their system in case of a data disaster. The hospital uses a nurse’s database mainly an Operational Database to keep track of their nurses, store and organise data. The current network architecture also uses a lot of bandwidth for processing data on each PC which is wastage of bandwidth.

The list of requirements for designing the new network will include the following:

- Client PCs and servers
- Capacity of the network i.e., how many users will be using the network on a daily basis.
- Bandwidth allocation, budget.

- Networking equipments like cables, routers, modems etc.
- Software and medical equipments being used by medical and non-medical staffs.
- And lastly, the thin-client/virtualisation software by which thin-client network works.

To implement thin-client network, it is necessary that the following requirements be met: [4]

- RAM and ROM depending on the CPU usage, performance consideration and software that are being used by that client or server.
- I/O devices like keyboard, mouse and network connectivity hardware.
- PC display hardware should support 8 bits per pixel, resolution of 640 x 480 pixel, contrast and brightness control.

1.7. OVERVIEW OF THIN-CLIENT NETWORK

Once the thin-client network has been designed and implemented, the network will be managed and administered by the network and system administrators. It is the responsibility of the administrators to keep track of routing, switching, bandwidth allocation, security and other factors to make sure that the network is being properly used by the users of CHC.

In a thin-client computing environment, all the data and applications are centrally stored on a powerful server. This server is responsible for data processing and screen updates and the output of the data processing is rendered to the client side. This server is capable of storing huge chunks of data and applications of all users. For the client to communicate with the server, thin-client PC's requires a display device (monitor), keyboard, mouse and basic processing power. The advantage of thin-client is that it has no moving parts such as fans or hardware. In thin-client, a normal PC's CPU is replaced by a small box which is lightweight and can be attached to the back of the client's monitor. Thin-clients are very thin, in terms of appearance, features and functionality and no data is stored on the client side.

For a thin-client network, a normal PC monitor or display device can be converted to a thin-client monitor. In simple words, the thin-client can be a normal PC with thin-client OS installed or a new dedicated thin-client device. Therefore for the organisation, it is not necessary to replace the all the existing desktops with new thin-client devices. Thin-clients functions as a normal desktop and can run on any OS like Windows, Linux etc and on any software.

1.8. THIN-CLIENT COMPUTING

1.8.1. IMPLICATIONS OF THE STUDY

A research and thorough study on the different types of thin-client computing will be performed. The types of thin-client computing will then be discussed with CHC and the best type will be chosen. This new network will then be implemented only in the hospital and research centre located in the medical city. Then at a later stage (next year), thin-client will be implemented at the clinics. The current LAN infrastructure being provided at the hospital and research centre will be taken into account and the new network will be designed to increase the network performance, efficiency and will be cost-effective. This new network will provide room for future growth in case the organisation is plans to expand or recruit more number of staffs.

Once the thin-client network has been deployed it will solve the current problems being faced by the old network. It will allow the medical staffs especially doctors and medical interns to access files and patient records even outside the medical vicinity. It will allow doctors to use tablet PC's or iPads for accessing patient records and other relevant information effectively. The network will reduce the risks associated with data theft and data recovery, reduce power consumption and new thin-clients can be added to the new network for the new employees who join the hospital and clinics.

As far as network security is concerned, the new thin-client network will give the perfect security for the medical records, files, business details, etc., including the confidential ones etc from external breach. The new network will then monitor and maintain a record of who all had accessed which all files and updated them. Even a record of which staffs have access to what data will be maintained in the network. This will provide easy administration and end-user support, increased reliability and security.

1.8.2. LIMITATIONS OF THE STUDY

The limitations of the newly implemented network will be found from surveys and questionnaires obtained from the users and technical staffs after the network has been implemented and tested. The feedback of the surveys and limitations of this project has been covered in this project.

CHAPTER 2. LITERATURE REVIEW

2.1. CONCEPTS OF NETWORKING

A network is a collection of computers and other devices connected to each other in order to exchange information. Each of these devices can be defined as a node, and each node has a unique address. These devices are connected by cables which can be a copper cable, fibre optic cable or wireless transmission or by the use of network software, in order to allow them to communicate with one another and exchange information. Once connected, the computers can share information, files, applications, printer and scanner or even browse the Internet.

In organisations, network computing is an environment where all the computers and other hardware devices like printer, scanner are connected to form a network. The range or capacity of this network can vary depending on the size of the organisation. Depending on the size of the organisation, a network can therefore be classified into the following [3]:

1. **Local Area Network (LAN)**: LAN is a computer network that connects computers and devices that are within a building or a residence. Mainly used in most organisations, offices, schools, or at homes.

2. **Metropolitan Area Network (MAN)**: A MAN is a network slightly larger than a LAN and usually spans a city. Mainly used by public entities like government organisations.

3. **Wide Area Network (WAN)**: A WAN is a collection of LANs which usually spans a country or the Earth. Internet is the largest WAN.

2.2. NETWORKING TERMS

1. **Workgroup**: A group of computers in a network that are connected to each other and share information and devices. Also known as clients in a network.

2. **Topology**: Arrangement of computers in a network. Star, bus, ring, mesh and tree are the different types of network topologies.

3. **Telnet**: Process to access a remote computer over the network.

4. **Protocol**: Set of rules defined for computers communicating on the network.

5. **TCP/IP**: Transmission Control Protocol/Internet Protocol is a protocol used by a large number of computers.

6. **SMTP**: Simple Mail Transfer Protocol is a standard protocol for exchanging mail over a TCP/IP network.

7. **Server**: A device shared by the users of a network.

8. **FTP**: File Transfer Protocol is a point-to-point transfer protocol for transferring texts and binary files between computers.

9. **VoIP**: Voice over Internet Protocol is a method for establishing two-way multimedia communications over the Internet.

10. **Routing table**: A routing table is used in TCP/IP routers to determine the destination of messages being forwarded.

2.3. TYPES OF NETWORK

The purpose of networking is to share information and this can be accomplished depending on the type of network chosen. Networks fall into two types: *client-server* and *peer-to-peer* [3].

- In a *peer-to-peer* network, computers are connected to each other via cables and this type of network does not have servers. Files can be shared between computers, and all the computers share the same network printer, scanner and fax machines. Networks that run Windows 95, 98 or NT as their operating systems are usually peer-to-peer networks. Peer-to-peer network are simple to set up, compared to a client-server network where only the computers have to be connected to each other via cables. But they have the following disadvantages like network is not centrally managed, it is not secure, limited number of computers can be connected to such a network and backing up of files is not easy. Peer-to-peer networks are typically used in small businesses (Fig 2.3.1).

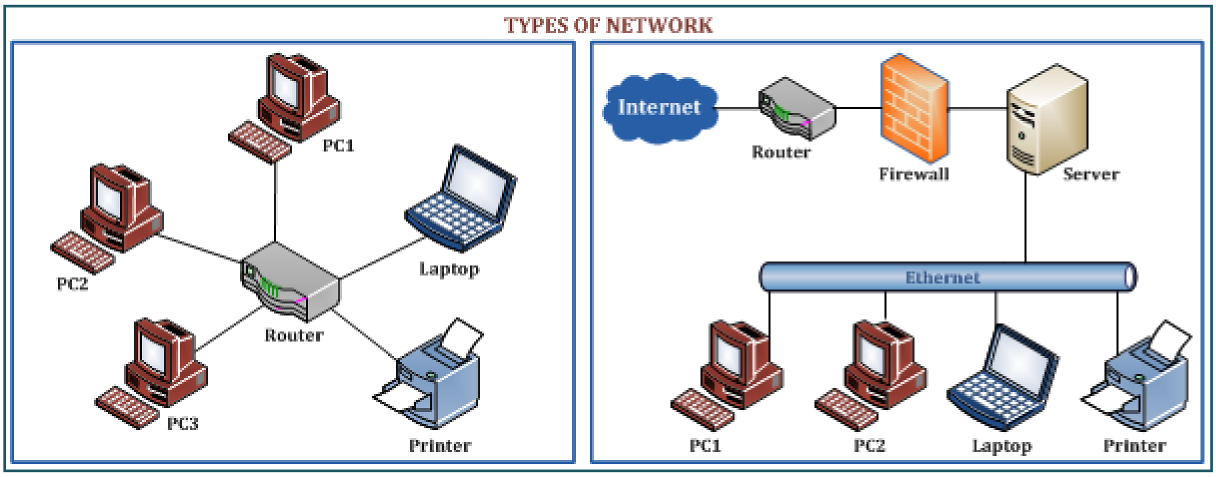

Fig 2.3.1 Peer-to-peer network [32]   Fig 2.3.2 Client-server network [32]

- In a *client-server* network, the client is a normal PC capable of processing and storing information. Each client in a network will have an Operating System and a number of software installed in them. Servers are powerful computers capable of managing files, printers and the network traffic. Clients rely on servers for resources like files, applications, printer, scanner and even processing power. Though a client-server network is expensive to implement compared to a peer-to-peer network, client-server network have many advantages: centrally managed network, easy access of information and easy backing up of files. Client-server networks have better performance and can accommodate large number of PC's (Fig 2.3.2).

2.4. NETWORK COMPONENTS

To build a computerised network, three primary components (Fig 2.4) are required which are:

- **Server**: Server is the main component required for a network. The function of the server is to provide resources and data necessary enough to perform a task. Servers can be of two types: dedicated server and non-dedicated server. Non-dedicated servers can be used both as a normal computer and as a server.

  Dedicated servers, as the name suggests, are those kinds of servers that serve a particular purpose for the users of the network. Different types of dedicated servers include the following:

  - *FTP Server* which provides the secure transfer of files between computers thereby ensuring the file security and transfer control [30].
  - *Application Server*, also known as appserver, supports all the high-end applications used in any organisation [30].
  - *Audio/Video Server* used for broadcasting multimedia content.
  - *Mail Server* for transferring and storing e-mails used in organisations. E.g.: Apache Web Server, Apache Tomcat. [30].
  - *Web Server* for delivering web pages to the Internet [30].
  - *Proxy Server* which acts as an intermediary to process the requests of clients seeking information/resources from other servers [30].
  - *Telnet Server* which enables users especially system administrators to log on to a host computer and perform tasks as though they are working on a remote computer [30].
  - *Virtual Server*: A virtual server is a server that uses one server and breaks into different virtual machines. This is mainly used when users need to share the same server at the same time. In simple words, a virtual server is a dedicated physical machine that can be shared by a number of users.
  - *IRC/Chat Servers* which allows the users of an organisation to exchange information among themselves.
  - *Fax Server* for handling in the incoming and outgoing fax messages.
  - *Print Server* for controlling and managing the printers used.

- **Workstation**: Workstations are the computers on which users perform computing tasks. Each computer must have an NIC installed in order for it to communicate with other computers or servers.

- **Resources** can be the network printers, fax machines, IP telephones, disk storage devices and other hardware devices.

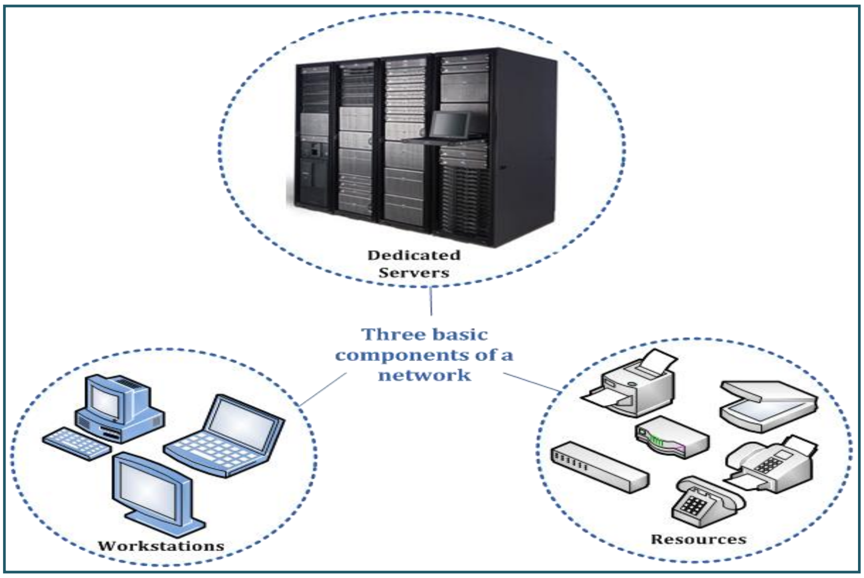

Fig 2.4 Primary components of a network

In order to make a computer or server operate in a network or connect to the Internet, different network components are required. These components can be classified into two parts: ***Hardware components*** and ***Software components***.

Hardware components of a network are those devices that are necessary and designed to handle certain network functions. These hardware components are also known as networking devices which consist of the following:

(i) *Router* is a device that transfers packets or data from source to destination or across different networks.

(ii) *Firewall* is a device designed to prevent unauthorised access to or from a network. Nowadays, a router comes with built-in firewall and modem.

(iii) *Network adapter* is an adapter that works as an interface between a computer and a network. Network adapters can be an internal network adapter or an external network adapter. Internal network adapter is also known as NIC which is installed on every computer in the expansion slot. An external network adapter is a separate device that is connected to a computer in the USB slot.

(iv) *Modem* is a device used for connecting to the Internet. Different kinds of modem include a cable modem, ADSL modem, GPRS modem, dial up or a Direct Internet cable modem used in big companies.

(v) *Switch* is a device that acts as a central connection point used for connecting computers to the network.

(vi) *Gateway* is used to connect two different networks.

(vii) *Wireless Access Point (WAP)* is a device used for connecting computers and devices to create a wireless network.

(viii) *Cables* used for transferring data from one point of the network to another.

(ix) *Network Interface Card (NIC)* is a must for every computer or device in the network. It is used for communication between computers and devices.

Software components of a network include the operating system like Windows XP, network operating system like Windows Server 2008 and other software used by the users of an organisation.

A network operating system (NOS) is an operating system designed to support the workstations and laptops that are connected to a LAN. Network operating system provides support for application and data sharing, printer sharing, managing Active Directory services and security. It also provides users with password protection on their accounts and network administrators with services to help control access to the network, use and administer the network. Examples of NOS include Windows Server 2008, Novell's NetWare, and Digital's OpenVMS etc.

2.5. DESIGNING A NETWORK

Designing a network can be a challenging task. In order to design an efficient, reliable, fast and secure network, it is important that the three basic components of the network (servers, workstations and resources) will have different technical specifications. It is therefore necessary to decide on the technical requirements of the various networking components. Despite technology bringing in new network components for maximum performance, designing and building a network is always a tedious task if proper planning and experienced technical staffs are not involved in the design, implementation and testing stages. With large organisations having branches worldwide, a virtual private network has to be designed for each branch so that the users of all branches can access information no matter where they are currently present. Carefully designing a network can reduce the complexities and risks associated with the growing network [2].

When designing a network, the following points must be considered:

- The type of organisation and its business, size of the organisation.
- Should a new network be implemented or should an upgrade be performed on the existing network?
- If a new network is to be implemented, who will be the users, what will be their requirements? Who will be the network provider?
- Bandwidth utilisation, range of the network.

- What functions will be provided by the network to its users?
- Should VPN be needed for remote users?
- What will be the budget to design the network?
- How many clients or workstations, servers and network resources will be needed?
- Whether the software and hardware will be compatible with the new network?

Designing and building a secure and reliable LAN consists of the following steps [6]:

- First is to draw the network diagram, a detailed one with floor plan especially for large organisations. Carefully determine where all the computers, servers and networking devices should be placed and then point it out in the diagram.
- Second is to determine whether a wired LAN or wireless LAN will be used. It is best to use a wireless LAN for large organisations as it will be easy to connect all the devices wirelessly using the built-in NIC's, routers, switches and bridges.
- Third, determine the range and how much bandwidth will be utilised. This is especially important for large organisations having a number of users.
- Fourth, decide on who will be the Internet Service Provider (ISP) and what will be the speed of the Internet connection.
- Fifth, is to purchase the networking components for the network. First and foremost, make a list of what all components needs to be bought, their technical requirements and then decide on what kind of router to buy and what will be its technical specifications. Then purchase the remaining components like cables, WAP's, switches etc.
- Sixth, after purchasing the components it is time to connect the computers, servers and network components to the network. Properly configure and set up all the devices so as to avoid errors.
- Finally, once the network has been designed and built test the network and troubleshoot any errors found.

2.6. THIN-CLIENT COMPUTING MODEL

2.6.1. WHAT IS THIN-CLIENT NETWORKING

Thin-client is a computer that relies on a powerful computer (server) to perform its tasks. In a networking environment, the client computer acts as an interface and the network server does the real computing functions like processing of data. While an old traditional computer requires a hard drive, CPU and its own set of software applications, a thin-client requires no fans for cooling, needs no software to be loaded on to it nor does it store data [7]. The software and data are all stored on the server (Fig 2.6).

The monitor for a thin-client device can be a normal monitor and can be operated with the keyboard and mouse. Thin-client is very simple in operation: switch on the device, log on to the server and start working. All that a thin-client needs is just sufficient power for it to work [7]. HP, Wyse, Sun Ray and Dell are the main retailers of thin-client. HP thin-clients are widely used nowadays as it is not expensive and provides the best thin-client solutions to enterprises worldwide.

In thin-client, all the software must be installed in the server only and the upgrading of any software needs to be done from the server only. This software can be then made available to all the users who require it. The server should be powerful enough to store huge volumes of data, software and other server software. IBM, Dell and HP are the retailers providing servers for thin-client computing of which many companies prefer IBM as it is very powerful in performance and other factors.

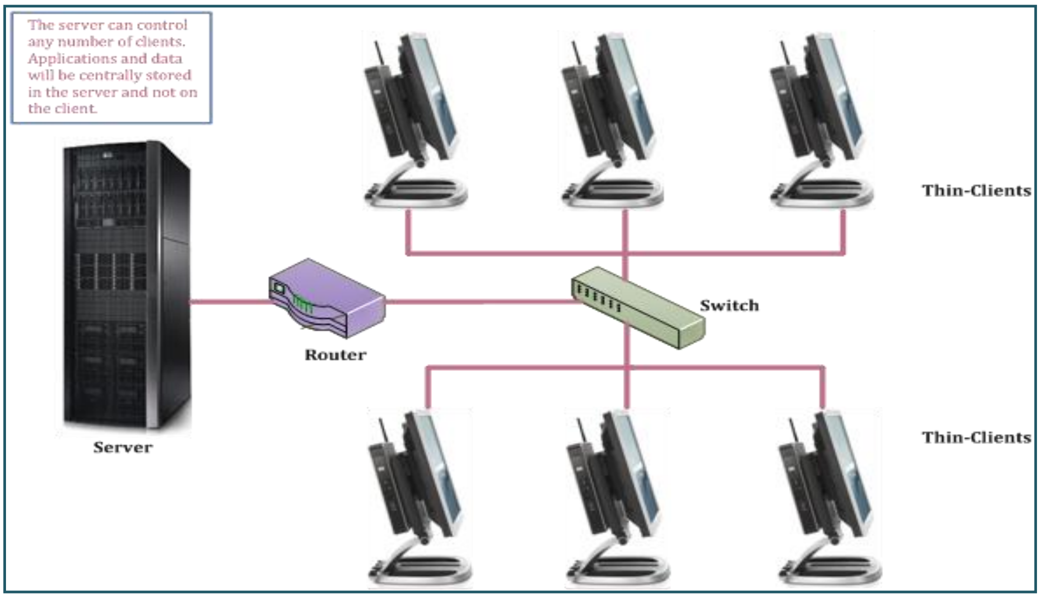

Fig 2.6 Model of a Thin-Client network [33]

There are four different types of thin-client computing involved:

1. **Traditional thin-client computing** – This kind of thin-client computing is meant for organisations that use the same kind of applications on a daily basis. For organisations using rich multimedia applications traditional thin-client computing won't be a good solution.

2. **OS Streaming** – Consists of thin-client devices that have a fast processor and RAM. Allows users to perform their tasks locally on thin-clients while all the data are stored centrally in the server.

3. **Blade PC's** – Gives users the full experience of a PC. Data and applications are stored in servers which gives the IT department ease of managing the network.

4. **Desktop Virtualisation** – Desktop Virtualisation will be used for this project and will be dealt in more detail in the next topic (See Section 2.7 page 14).

2.7. DESKTOP VIRTUALISATION

Virtualisation is the process of creating a virtual version of an Operating System, server or any other storage device. A simple example of virtualisation is disk partitioning. When disk partitioning is done, the hard disk space is divided into two separate hard disks.

Desktop Virtualisation is the most popular and successful technology in thin-client computing that is being used in many organisations like schools and hospitals. Desktop Virtualisation is a technology where multiple virtual machines can be managed by a single server. A virtual machine is a program or software that can run its own Operating System and applications as though it were a normal desktop. The server will be a Virtual Machine server that stores applications, data and Operating Systems of users. Different virtual machines can run different Operating Systems and multiple applications on the same computer. A virtual machine is similar to a normal desktop and is run by a single or multiple users.

Desktop virtualisation separates applications, data and the Operating System from a user's desktop. All the users' data, applications and Operating System will be stored in the server only nothing will be stored in the user's desktops. This means when the user logs on to his/her desktop, that particular user's applications, data and Operating System will be loaded on to the desktop from the server. Users who may be geographically scattered can access their data from the server once they are connected to their LAN. Desktop Virtualisation solutions are provided by VMware, Wyse, Citrix and Sun VDI. For this project VMware's desktop virtualisation will be used for implementing the new network.

Desktop virtualisation has shown maximum performance for the organisation that have used it. This technology allows the network administrators to administer, control, manage and maintain many user desktops on a single, central computer or server. Overall costs required for maintaining and upgrading the network are drastically reduced, thereby reducing the number of hardware and increasing the server's performance. Desktop Virtualisation has improved desktop management and control with faster deployment of desktops and fewer IT support calls [28]. This technology has proved to be the best thin-client solution giving the organisations networks the highest availability and performance and reducing capital costs.

2.7.1. HOW DOES DESKTOP VIRTUALISATION WORK

The following components are necessary to make desktop virtualisation work:

1. Thin-client device with monitor, keyboard and mouse,
2. VMware software to be installed in the client and server side,
3. Server based operating system either Windows or Linux,
4. Host and guest operating system: A host operating system is the Operating System installed by default on all desktops. A guest operating system is the Operating System installed on top of host OS in the virtual machine. A host OS can support more than one

guest OS. For virtualisation, both host and guest OS must be installed on the same virtual machine. In this way, many applications and resources can be run and shared respectively, on the same desktop at the same time.

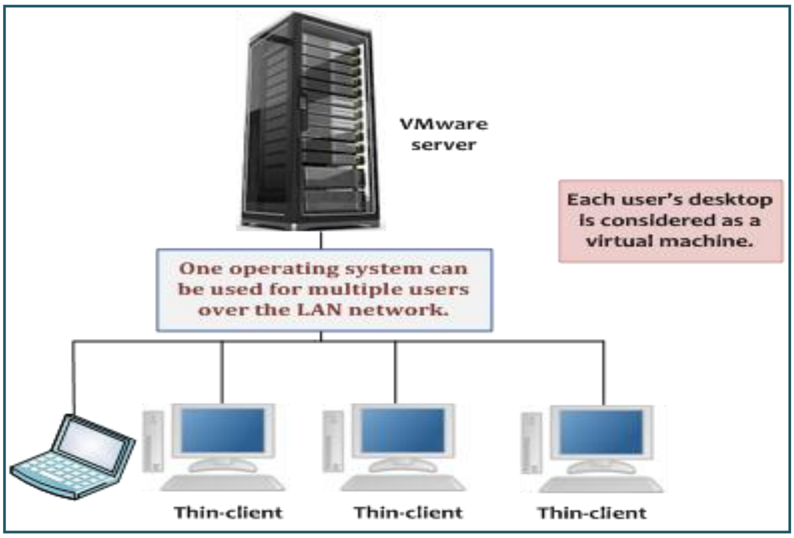

Fig 2.7.1 How desktop virtualisation works

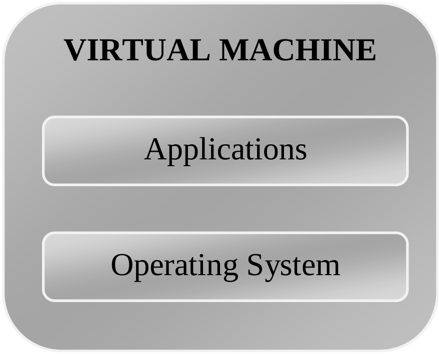

Fig 2.7.2 Virtual Machine

As seen in Fig 2.7.1 for desktop virtualisation to work, desktop virtualisation software needs to be installed on the server. When a user logs on to his computer using his username and password, the user's credentials is sent for authentication to the Active Directory domain services. Once logged on, the user is allotted his virtual machine, which is nothing but a client PC, from the list of client IP addresses available. Both guest and host Operating Systems have to be installed on the virtual machine in order to make it work. Guest and host Operating System is useful if the virtual machine is being shared by more than one user. The user can switch between the Operating System of his choice by just choosing the OS and logging into the system [8].

The working behind desktop virtualisation is as follows: A Virtual Machine (Fig 2.7.2) image file is created on all desktops. This image file contains the guest and host Operating System, applications, files and system settings of that particular desktop. A virtualisation engine, mainly a Virtual Server, runs this VM and this VM behaves like a regular computer. The Virtual Machine is known as a host and it can be a user's desktop or a centralised server. A guest and host operating system must be installed on the VM image file so that files and resources can be shared efficiently and reliably between the user's desktops. For desktop virtualisation, it is necessary to purchase the Virtual Server, thin-client devices and the virtualisation software.

2.8. BENEFITS OF DESKTOP VIRTUALISATION

Over the years, desktop virtualisation has provided solutions to many organisations facing problems with their client-server network. Companies like Microsoft, Wyse, Citrix, Sun and VMware that provide thin-client solutions have developed the best software and network protocols that allow network administrators to deliver smooth running of applications from the server to the thin-client desktop. Following are the benefits of a desktop virtualisation:

- **Management and Security:** Desktop virtualisation has made the job of network administrators simpler by giving them an easy and centralised way to monitor, control and manage many user desktops. Each user's desktop appears as small boxes making it easy for the administrator to control and easily provide remote desktop support. Instead of handling each desktop separately, network administrators can handle multiple desktops using the VM image files. Each image file is of a user consisting of that user's applications and data and appears as tiny windows on the server computer [12].

- **Central storage and increased life span:** With desktop virtualisation, all the applications, files and Operating Systems are centrally stored on servers. This leads to greater security because data and applications are stored on powerful secure servers rather than on individual computers. Also, the need for transferring applications and data from the client to servers is reduced thereby extending the life span of clients and hardware.

- **Improved support:** Using virtualised desktops, there is no need for the IT support staff to go to each computer and fix technical problems. The support staffs can remotely solve the problem from the server room itself using that user's VM image file. This will increase the productivity for both the IT and end-user staffs.

- **Reduced costs:** Using the traditional client-server network, the annual IT costs for an organisation increases year after year due to the frequent maintenance and upgrades associated with the network. Deploying desktop virtualisation reduces the annual IT costs or TCO to a great extent as there is no need to buy extra hardware and PCs. Desktop virtualisation has the advantage of converting old traditional PC to a new thin-client one thereby reducing cost to buy them.

- **Environment friendly:** Thin-client virtualisation has become an eco-friendly green computing as thin-clients use less power, have a longer lifespan and moreover no fans. So heat dissipation is greatly reduced. Thin client devices are small, lightweight and easy to carry.

2.9. DRAWBACKS OF DESKTOP VIRTUALISATION

Following are the drawbacks of desktop virtualisation:

- Initial investment in buying the virtualisation software, licence and a powerful central storage server will be little high [13].

- If there is congestion in the LAN, the display quality of the desktop will not be good.
- If the server goes down, the whole network will fail to function disrupting the users' work.
- Users will find it difficult to adapt to this network if they are not given training on how to use this network before hand.

2.10. BEST PRACTICES OF DESKTOP VIRTUALISATION

The following section deals with the best practices that every organisation must consider when implementing desktop virtualisation [14]:

- **Update security policies:** It is very important that the IT department of an organisation revise and update their security policies and procedures so that the policies are in compliance with the new virtualisation features.
- **Virtual Desktop Access Control:** The IT department of an organisation should use Active Directory or LDAP for user authorization, authentication and providing remote access control for users.
- **Remote Access:** This feature is important for the remote users who are not physically present in the organisation and require access to the network. If in case, a remote user wishes to access the network, it must be verified that he/she is running the organisation's VPN from a trusted computer or laptop.
- **Isolation Control:** For virtual desktops that run on host PCs with separate operating systems, it is important to hide the applications, files and system settings from the host PC so as to avoid malware, copying of data or data loss. This is important if one host PC is being used by more than one user
- **Security Scan and Update:** Almost all networks will have the Network Access Control (NAC) feature that can scan all software, anti-virus software, firewall to ensure that the network is secure and up-to-date. Similarly, virtualised desktops must be scanned prior to users logging on to their respective desktops.
- **Operating System Check:** The Operating System must be scanned and updated on a regular or weekly basis to ensure that the OS is secure. Organisations must have proper scanning tools to ensure that the OS running on the host PC or user's PC have security patches and service packs.
- **Data Protection & Encryption:** Proper data protection, encryption and decryption features must be used especially for virtualised desktops so as to ensure that confidential information, patient records, employee information or other information is not exposed to a third party. Confidential information must be properly encrypted when sending it over public networks using SSL or VPN encryption.

2.11. STEPS TO IMPLEMENT DESKTOP VIRTUALISATION

Desktop virtualisation can be successfully implemented to overcome the disadvantages of client-server network and solve the network problems of an organisation with careful planning, design and implementation and involving experienced technical staffs in each stage. Implementing virtualisation like a normal client-server network will not make virtualisation a success because it has to be implemented based on research and in an orderly fashion. The steps mentioned below demonstrate the proper way to successfully implement virtualisation for an organisation:

1. **Choose the right virtualisation solution**: The first and foremost step in implementing desktop virtualisation is to perform a thorough research and study on desktop virtualisation, its use and how it will solve the network problems of an organisation. After proper study, a proper market study has to be done on the solution providers (software) of desktop virtualisation. Once a study has been done it is time to choose the best software solution based on the kind of solutions that software provides and whether it will help solve the current network problems [15].

2. **Compare solution with current network**: Next is to compare the solutions that the software provides with the problems of the current network. Check whether the solutions available will help solve the problems of the network.

3. **Purchase additional components or devices**: Implementing a new network or upgrading an existing one will require some additional components to be purchased like servers, PC's etc. A thin-client network has the advantage of converting a traditional PC to a thin-client one. But the servers cannot be converted; it is best to purchase an additional server capable for virtualised network. This server also known as virtual server must be purchased keeping in mind the storage requirements, functionality, technical requirements and cost. Choosing and buying a new virtualised server will require the help of experienced network staffs.

4. **Technical specifications for clients and servers**: A thin-client network stores all data and applications on a central storage server; only screen updates and data results are displayed on the user's desktop. For such functionality, it is necessary that all existing monitors have the required display, graphics, memory and processor. Similarly, a server will also have requirements of minimum memory allocation and other factors. It is very important to check either if the existing software will be compatible with thin-client or if the compatible version should be purchased with licence and this includes the server and client OSs.

5. **Upgrade network storage**: Upgrade the storage of the current network as desktop virtualisation stores the entire organisation's files, applications and other data in the main virtual server. So it is always recommended to have a server which can store minimum of 2TB of data. Also, it is recommended to have an external storage disk like NAS, disk drives or tapes to keep an additional copy of data and applications. This storage disk is very useful when backing-up data to implement the new network [15].

6. **Deploy implementation in stages**: Even with proper planning and design of the network, it is not always that desktop virtualisation is implemented successfully. Implementation requires dividing the whole process into stages, each stage being implemented separately like on a day-to-day basis. Implementing in stages will help in identifying errors or rollouts and rectifying them [15].

7. **Security measures**: Make sure all security features and patches have been properly added to the software especially on the OS. Security updates for OS needs to be performed regularly so to have the latest security patches and updates in order to avoid any kind of unauthorised access [15].

8. **Testing**: Testing is an important part that has to be done before allowing the users to use the new network. It is also important to test whether software and hardware are properly installed and configured.

9. **Train users**: Many users will find it difficult to adapt to the new networking environment if training is not provided. After testing the network, train the users so that they can use the network well without any technical support [15].

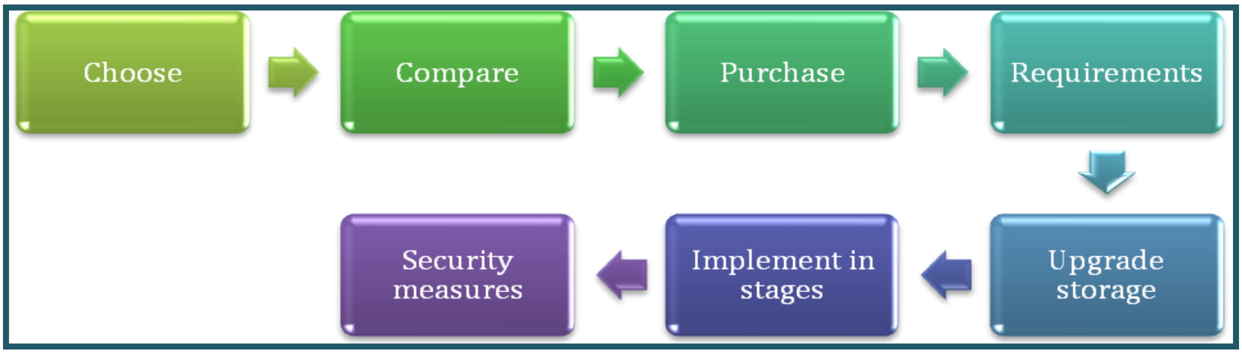

Fig 2.11 Steps to implement desktop virtualisation

2.12. DESKTOP VIRTUALISATION IN THE HEALTHCARE SECTOR

Healthcare is one of the fastest growing sectors that constantly undergo rapid transformation as hospitals worldwide moves towards new technologies and paperless work. Many hospitals and clinics worldwide are constantly under pressure to give the best health care to their patients while maintaining the highest level of patient record security and privacy. They use rich multimedia applications by which they can ensure that their patients receive the best health care available. Information Technology is one such sector that provides and supports hospitals and clinics with back-end technical support for applications and other functions, and today, IT benefits healthcare with rich multimedia, browser-based applications and other computing.

With the introduction of iPads, hospitals worldwide are adapting to use iPads by which they can move around and check patient status, EMRs and other medical data even from the patient's bedside. Remote users who are not geographically present in the hospitals and require access to the network have made healthcare depend fully into IT for their daily interactions and operations. The growing need of EMRs, iPads /tablet PC's and other devices have shown the importance for healthcare organisations to provide their staffs with reliable, secure, easy and shared access to patient data and applications. Most of the healthcare organisations are seeking to deploy server-based and desktop virtualisation thin-client technologies, most of whom have become successful. Studies have shown that almost 75 to 80 percent of the healthcare organisations worldwide have already replaced their client-server networks with thin-client network. Medical staffs can now easily connect their handheld devices and other medical equipments to thin-client network and perform their job tasks with great confidence.

HCI Internet Protocol Television is one entertainment service provided to the patient's room. HCI IPTV is meant for patients so that they can watch TV, browse the Internet, play games and contact their families while reducing a lot of hardware. HP and Wyse are the two most reliable thin-client solution providers. HP thin-clients are more affordable compared to Wyse. With HP thin-clients (Fig 2.11), medical staffs can ensure the security of patient records and patient history. HP thin-client devices are so lightweight and compact that they do not have fans, thereby reducing the risk of dust and spreading airborne diseases. They can be used to improve clinical workflow, enable centralised shared access to patient records and help healthcare professionals increase productivity thereby reducing medical errors [16].

Fig 2.12 HP Compaq thin client

Below mentioned are some of the hospitals who replaced their client-server network with thin-client virtualisation:

- Pacific Hospital, USA is a teaching hospital that replaced their client-server network with HP Compaq thin clients. The IT support staffs of this hospital were finding it difficult to support their users present in different locations. They were finding it difficult to maintain the old desktops and work with their current ERP applications. The department then decided to implement thin-client virtualisation and found that their Total Cost of Ownership (TCO) had drastically reduced, improved services, centralised management and supported their large number of staffs and moreover, maintaining the new network only required very few technical staffs [17].

- Frederick Memorial Healthcare had their servers which were approaching its end of life. They had to decide whether they had to replace old servers with new ones or implement virtualisation. They implemented virtualisation in the middle of 2011 and found that they could deploy a server in 30 minutes. They even reduced their data centre racks from 16 to 11, decreased energy consumption to 35% and saved a lot in their annual hardware costs [18].

- Oasis Hospital in Al Ain, UAE successfully implemented desktop virtualisation by the first quarter of 2009. The hospital now has 40 virtual machines running on 20 virtualised servers. They have said that thin-clients became very useful for them especially for their doctors and nurses who move frequently between their workstations [19].

- Seton Family of Hospitals in Texas, USA found that their clinicians took 30 to 45 seconds to log on to their computer, open their applications and start working from where they had started earlier. They implemented virtualisation and found that the virtualised desktops saved each clinician time in logging on to their systems, thereby freeing them and attending to patients and other clinical works [21].

- Huntsville Hospital, North Alabama wanted to replace their old network with virtualisation. They wanted to replace their large number of desktops and servers and had a data centre that had just 15 minutes of battery backup when power cuts happened. The hospital implemented VMware desktop virtualisation and used IBM rack servers. They found that they could reduce and improve a lot in paperwork, applications and other devices.

- Interfaith Medical Centre, New York already had virtualised servers but had not replaced their old desktops. They were looking to reduce the costs associated with maintaining their old desktops. They implemented a centralised thin-client computing environment and found that their overall hardware costs had reduced a lot; thin-client was more reliable and virtually eliminated the need for technical support.

City HealthCare (CHC) is one such healthcare organisation based in the Middle East who has been using the client-server network for the past few years. They had always wanted to replace their current network as the medical staffs were facing a tough time with the network: logging to the systems takes time especially with the older computers, constant virus alerts, frequent technical problems, slow network performance, server failure and downtime and high annual costs associated with maintaining and upgrading the network. CHC thought of upgrading the existing network but later on found that upgrading wouldn't help solve the current network problems.

Implementing a virtualised thin-client network will help solve the current problems being faced by the network and its users. The reason for choosing a virtualised thin-client network rather than a simple thin-client network is because virtualisation has helped solve the network issues faced by many hospitals and organisations worldwide. The new network will help in having a centralised and controlled network management, easy monitoring of users activities, reduced Total Cost of Ownership thereby allowing CHC to save money, reduced power and energy consumption, reduced downtime, more life span for the computers, servers and other devices, easier data backup and recovery and secure network with high performance and reliability. Every user's desktop screen will appear as small windows on the virtual server once a desktop virtualised network is implemented.

Virtualised thin-client has more advantages compared to the traditional thin-client network. Doctors, nurses, physicians and clinicians can access patient records, lab results and other medical related data even from the patient's side by using their handheld devices or tablet PC's. There is no need of having to move the monitors to the patient's side in order to access medical data. Medical interns can access their lecture notes with the help of a virtual private network. Remote users who frequently travel can also access both business and medical data when outside the CHC vicinity. Virtualised thin-client computing is being implemented in many healthcare organisations worldwide and is the best in today's advancing technology.

2.13. LITERATURE REVIEW SUMMARY

In short and simple terms, a network allows computers to exchange data and share the same resources and it consists of client/desktops, servers and networking components. In order for computers to communicate with each other, each computer must have an NIC. There are different kinds of servers and each server serves a particular purpose. For successful implementation of a network, it is necessary to properly design, plan, choose and buy the servers and networking components. Buying a router with built-in firewall and modem will be a suitable option. Choose a router that has got good wireless range, this is especially important when implementing a network for large organisations. Also choose a server that is powerful enough to support the entire users data and applications.

There are types of networks used: peer-to-peer and client-server. A peer-to-peer network consists of computers that are connected to each other via cables using a router and switch. Such networks do not have servers and lack in terms of security and performance. This kind of network is used in small organisations having fewer staffs. On the contrary, a client-server network consists of clients and server. All the clients are connected to the server using switches and cables. Compared to a peer-to-peer network, client-server network is more secure, reliable and can accommodate more number of people. But with advancement in technology, client-server networks have lacked in security, network downtime, reliability and cost. It also has become difficult to maintain and upgrade a client-server network when the numbers of users grow. Also organisations have found their annual IT costs increased tremendously when using client-server network.

As a solution to the underlying disadvantages of a client-server network, thin-client computing was introduced. Server-based and virtualised thin-client computing are the most popular and successful thin-client technologies being used. Virtualised thin-client is being used and implemented in many organisations because of its many advantages: more centralised network management and administration, multiple machines can use the same server, lesser downtimes, data and applications are locally stored on servers, high performance, secure, reliable and cost-effective.

CHAPTER 3. CURRENT CHC NETWORK SETUP

3.1. NETWORK STATUS

As present, network being used in CHC is the traditional client-server network framework. They have a separate server room located inside the IT department and are accessible to the network and system administrator only. A surveillance camera is fitted on top of the entrance of the server room so as to monitor who is entering the server room. The server room consists of routers, switches, modem and servers all housed in server racks. The different servers used are PABX, Exchange Server 2007, and Windows Server 2008 with remote desktop services, CCTV video server, data and application servers.

In addition to this, the server stores business details, employees details, patient records, financial data, user data and a backup of user's data is stored on all client PCs. Since the employee strength of CHC is very large, the load on the server has become high and very slow in terms of performance. CHC has recently complained that the server load was too much that it could crash any time. So they have advised their staffs to backup their work in their systems. Apart from this issue, the network is very slow; employees are finding it really difficult to perform their work faster on the network. The network being used also have the following shortcomings: more prone to security attacks, high maintenance costs, constant desktop repair, and frequent network disconnection due to the number of users using the network and it is not reliable.

CHC requires a fast, secure and reliable network which can solve the current problems being faced with the network. The reason for doing this project is to design a new network which is Thin-Client and this will help solve the problems being faced by the organisation.

3.2. EXISTING NETWORK DESIGN

Currently the network is built according to Cisco standards and Etisalat is their Internet provider. The existing network consists of networking components and medical equipments which are installed and being used according to the medical standards. The networking components consists of a router with firewall installed, 24 and 48-port enterprise managed switches, web server, database and application server, PABX server, Exchange Server, IP telephony, Wi-Fi with access points on all floors and surveillance cameras. All these networking equipments along with the medical equipments, software, medical applications like Electronic Medical Records (EMR), EHR's, audio & video conferencing, internet, file sharing and printing services together form the CHC network. The routers, switches, different servers that are mounted on racks are all located in the IT server room. Two special monitors are located in the IT room, one to monitor the bandwidth utilisation plus users activities on the network and the other to record surveillance cameras in and out of the CHC vicinity. Surveillance cameras and Wi-Fi access points are located at various positions on all floors of CHC hospital and clinics.

The following are the list of users who use the network on a day-to-day basis:

1. Hospital staffs: Doctors, surgeons, nurses, lab technicians, clerical and administrative staffs.
2. Clinic and research centre staffs
3. IT department: IT manager, IT helpdesk support staffs, IT administrator, system and network administrators.
4. Medical interns who work with the hospital, clinics and research centre, and
5. Board of Directors and members of senior management who own and manage the business operations of CHC.

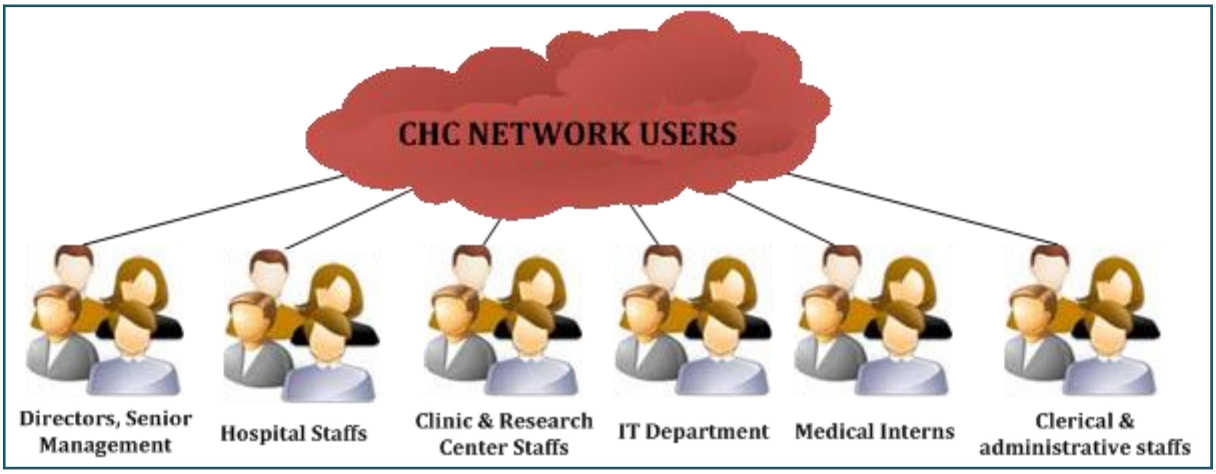

Fig 3.2 Diagrammatic Representation of CHC Network Users

3.3. NETWORK DISTRIBUTION

In CHC hospital, the networking equipments like router, switches, servers mounted on racks with a server monitor are all located in the server room next to the IT department and access to this room is permitted only to the IT department. The IT department and server room are located in the first floor of CHC. Each department of CHC have desktops, document scanners, network printers and IP phones. Each department has a head doctor and each head doctor has a desktop. The doctors are allowed to bring their personal laptops and do their routine works on them. The X-Ray room and lab are equipped with PC’s and network printer for lab technicians’ use. There is a separate training lab in the first floor mainly meant for the medical interns (trainees) which houses 40 PCs, document scanner and a network printer.

Fig 3.3.1 shows the physical LAN arrangement of CHC Hospital.

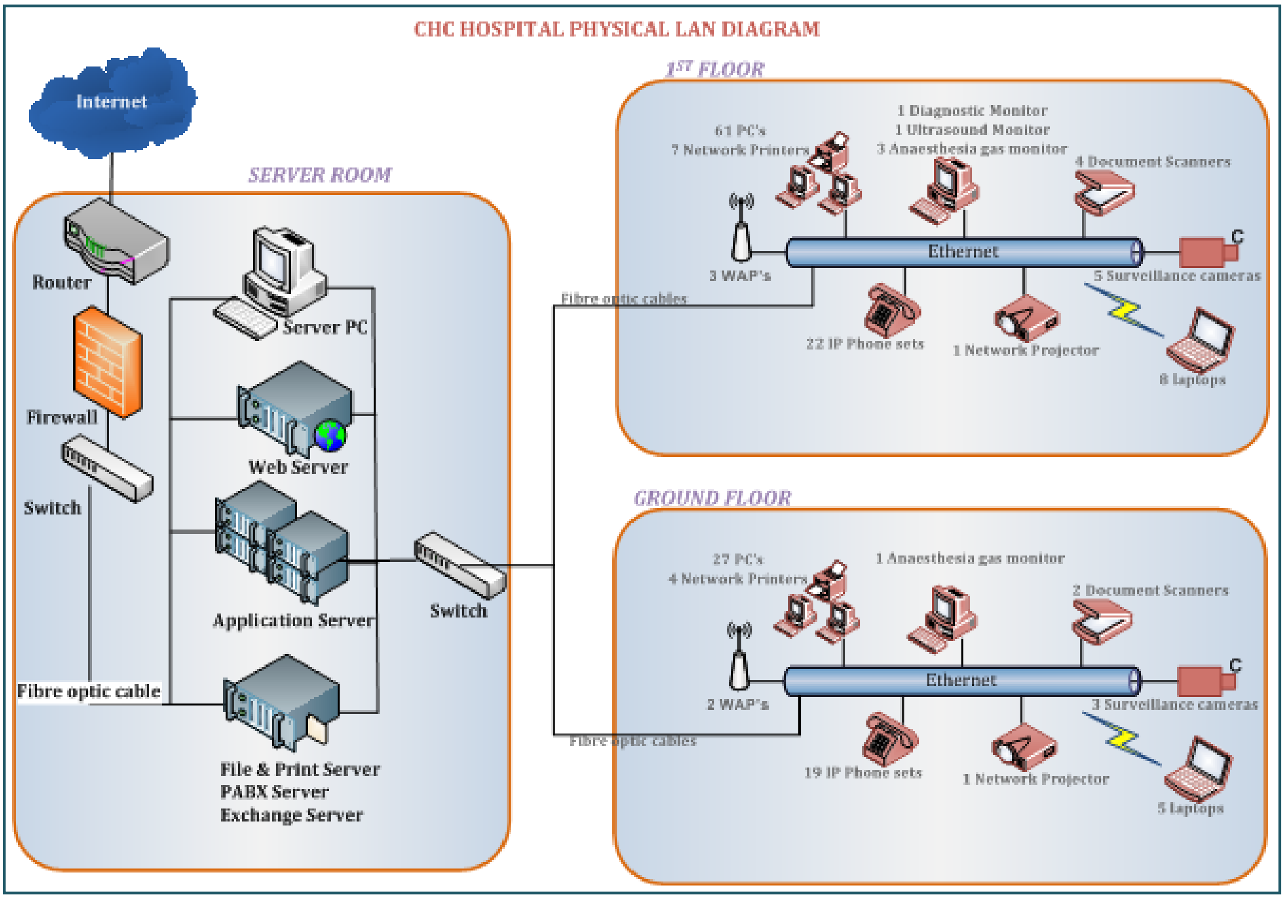

Fig 3.3.1 Physical LAN diagram of CHC Hospital

The above figure of the LAN arrangement of CHC hospital is self-explanatory. The PC's, network printers, scanners, medical equipments, WAP's and network projectors are connected to the switch using fibre optic cables. This switch is then connected to the servers in the server room. There is Wi-Fi in the hospital which is meant for the medical staffs (doctors) who wish to bring their personal laptops to work.

In the CHC clinics, the networking components like routers, firewalls, switches, fibre optic cables, servers mounted on racks with a server monitor are all housed in the IT departments of both clinics. The clinics have PC's, network printers, scanners, WAP's, IP phone sets, dental equipments and surveillance cameras. The clinical staffs do not work with rich media applications and they work with applications that use fewer graphic. Fig 3.3.2 shows the physical LAN diagram of the CHC clinics.

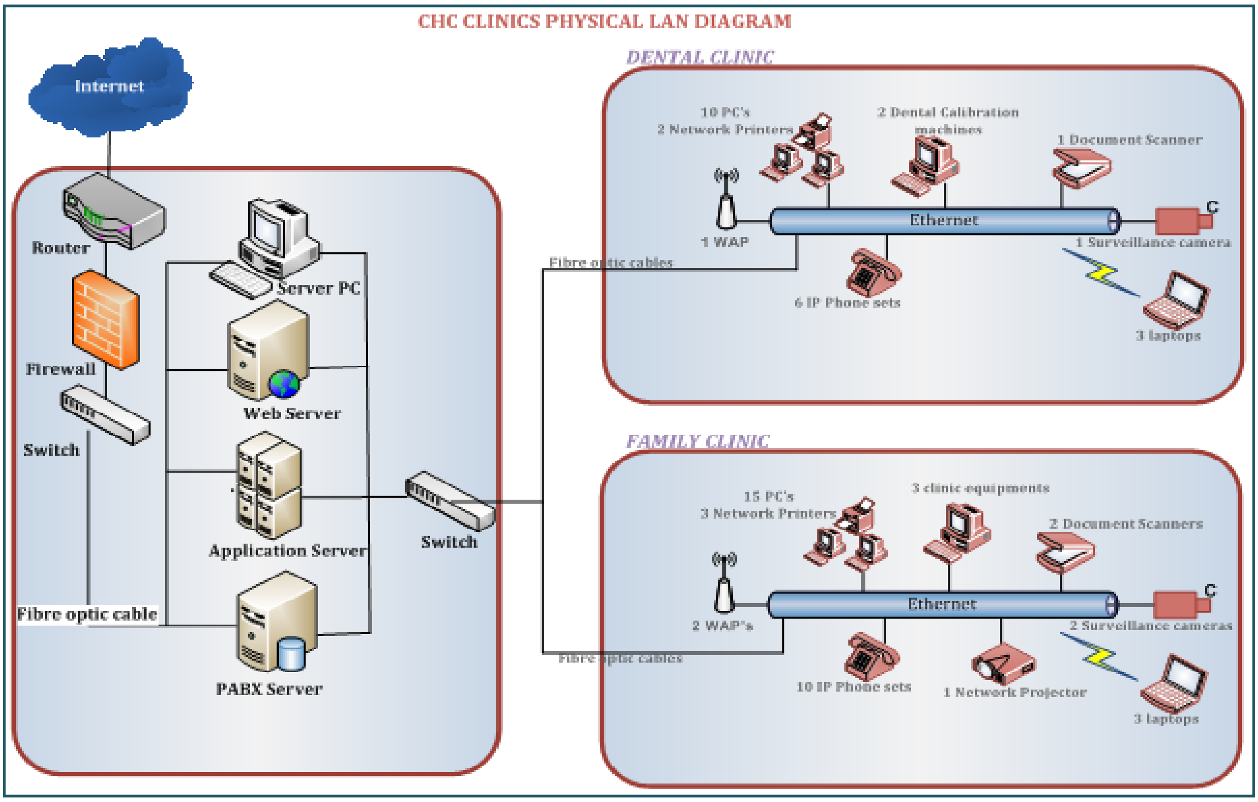

Fig 3.3.2 Physical LAN diagram of CHC Clinics

The servers used in the clinics are not the high-end servers. This is because the clinics have less number of staffs compared to the hospital and research centre. Clinical users use medical applications that do not consume much graphics but the network in the clinics is poorly maintained.

The Diabetes and Research Centre of CHC consists of the Diabetes Clinic, Eye and Foot Clinic, Nephrology, Patient Education, Physiotherapy and a bariatric surgery unit. The Centre conducts CHC medical education for doctors, nurses and interns and an awareness campaign for both its patients and CHC medical staffs on a monthly basis. The centre houses medical equipments which uses the CHC client-server network. Fig 3.3.3 shows the physical LAN of CHC Diabetes & Research Centre.

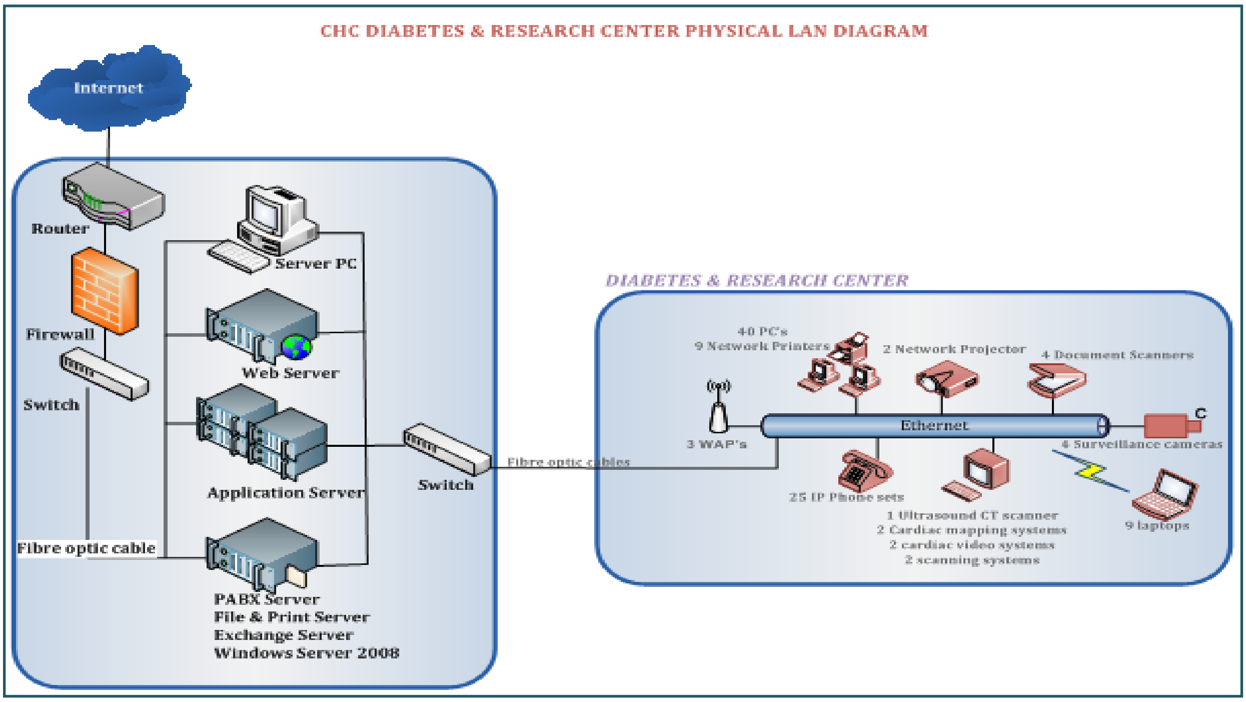

Fig 3.3.3 Physical LAN diagram of CHC Research Centre

CHC research centre and hospital use high-end server due to the large number of staffs using the network on a daily basis. The application and database servers are not high-end servers and therefore are not powerful enough to store large volumes of files, applications and databases.

CHC has been using the client-server network architecture for the past few years. All the medical staffs of CHC uses medical applications like Electronic Medical Records, X-Ray imaging software and much other medical software. This software uses rich media and with the client-server network, the users of CHC are finding it difficult to perform their routine tasks on this software as the current network is slow. In addition to the slow network, the cabling system of the network is extremely jumbled up that it has become difficult for the network technician to solve any technical problems related to the network. Adding new PC's to the existing network will only increase the load on the current network thereby making the network servers to crash anytime.

Also, CHC hospital is moving its training lab for their interns to the Research centre and they require the new lab to have the thin-client network which will enable their medical students to use the medical applications with high performance and simplicity.

3.4. SOFTWARE APPLICATIONS

The table below (Table 3.4) shows the list of software being used by the medical staffs of CHC. CHC is currently being owned by SEHA, Middle East's largest health services company and therefore most of the healthcare software solutions are provided by Cerner and Meditech.

SR.NO	SOFTWARE	USED FOR	USERS
1	Cerner Millenium PowerChart	EMR solution to view and exchange patient data.	Staffs of hospital and research centre, medical interns.
2	Cerner CareAware Multimedia	EHR solution for clinicians to store, manage and access all types of multimedia content like ECG's, radiology images etc.	Clinical staffs, medical interns.
3	Cerner Image Distribution	Provides hospitals and clinics with fast and secure access to patient images.	All medical staffs of CHC including medical interns.
4	Cerner Critical Care	Provides a summary of patient's health record to the staffs of ICU.	ICU staffs of the hospital.
5	Cerner Critical Outcomes	Extract specific data from patient record for use by paediatricians.	Paediatricians.
6	Meditech Emergency Department (ED) Management Solution.	Manage patient care, document treatments and track patient flow from a desktop.	Emergency Department staffs of the hospital.
7	PedHeart	Cardiology educational software	Medical interns and patients.
8	Blackboard Collaborate	Interactive learning software	Medical Interns.
9	Ace-Dental	Dental software program	Dentists and dentist trainees.
10	Birlamedisoft	X-Ray software	X-Ray lab technicians, doctors and nurses.
11	PACS (Picture Archiving and Communication System	Radiology software program for diagnostic imaging.	Staffs of radiology department.

Table 3.4 Software applications of CHC

Apart from the above mentioned applications, CHC uses the following software for their daily operations:

- *MS Office 2007*, *SharePoint 2007* and *Crystal Reports*
- Database management software – *Microsoft SQL Server 2008* and *Oracle 9i*.
- Network monitoring & management software - *OpManager*
- Antivirus software - *NOD 32* and *Norton*

- *Adobe Reader* and *Flash player*
- Accounting software – *Tally 9*
- Video conference software - *Cisco Webex*
- Disk defragmentation software - *Raxco*
- CD/DVD burning and video editing software - *Nero*
- Web browsers - *Internet Explorer*, *Google Chrome* and *Firefox*.

Windows XP Professional Edition is installed as the operating system on all desktops of CHC network. The doctors who bring their personal laptops to CHC have Windows 7 installed in them. ***Windows Server 2008*** is the network operating system being used currently. Due to the current set up of the client-server network, all the software updates are done on the individual desktops. The antivirus software (NOD 32 and Norton) is updated automatically on a daily basis when the CHC network is connected to the internet. The users use Microsoft Outlook for mailing documents within the CHC network. Social networking sites like Facebook and Twitter are blocked and the users are not allowed to upload audio or video on the Internet.

All the medical software being used (See Table 3.4) consumes high-bandwidth for video streaming and hence requires the systems to have a high graphics card to stream the video. Since all the videos, x-ray images and other multimedia contents consume more storage space, CHC requires a large hard disk which is capable of storing large amounts of data.

As mentioned in this project, VMware will be used as the desktop virtualisation solution. VMware is a corporation that have a variety of software solutions for implementing desktop virtualisation of which *VMware View* will be used along with virtual servers. A compatibility test was performed to determine whether the existing software were compatible of being thin-client. The results of this test have been revealed in Chapter 8 (See Section 8.1.7 page 59).

3.5. NETWORK MANAGEMENT

The network is managed and administered using Windows Server 2008's *Active Directory* services. All the desktops, networking components, servers, hard drives, licence software CD's have a label which contains an identification number of that device and list of the ID numbers are maintained by the IT administrator. No users are allowed to take any removable media that belongs to CHC with them. An inventory of all medical equipments and IT stationary are maintained by the biotechnical engineers and IT administrator of CHC respectively.

The existing network utilisation is at its maximum limit during morning hours as this is the time when more number of patients visit CHC hospital, clinics and research centre. During the peak hours, patient data, X-Ray images and other patient related multimedia content are transferred from doctors to nurses and vice versa and it is at this peak time when the network slows down. Applications and data take time to load and update. In addition to managing the network, CHC has a finger-print time attendance system which is managed by the HR department of CHC. This system records the attendance of all users by taking note of the time they entered CHC and the time they left.

3.6. DESKTOP & USER ACCOUNT ALLOCATION

All non-medical staffs of CHC are allocated an individual desktop. For the medical staffs, one desktop is used by more than one user. But in the training lab, every medical intern is allocated an individual desktop.

Every user of CHC is allocated an individual username and password for the PC they are allocated to use. No two users have the same username and password. Using the username and password allocated, the user can log into his/her system. It is the IT department who allocates their users a PC, username and password and the list of the usernames and passwords are maintained using the *User Account Control (UAC)* feature in Windows Server 2008. The users of CHC are allowed to mail documents, files, images etc. by using Microsoft Outlook only. During work hours, users are not allowed to browse social networking sites like Facebook and Twitter or even upload videos on the Internet. The activity of each user is monitored by the network administrator using the network management and monitoring software *OpMonitor*. Using this software, the administrator can monitor the files accessed by the user, websites visited, amount of disk space taken by the user to store his/her files etc. After work hours, users are required to log-off and shut down their systems. Servers are on throughout.

3.7. NETWORK SECURITY

The server room is located next to the IT department and houses the router, firewall, servers mounted on racks, fibre optic cables, switches, modem, gateway provided by Etisalat, a network printer and a server PC. This room is kept locked at all times and the IT department is responsible for any loss or mishandling of equipments. The IT manager, network and system administrator are given access to this room. No other personnel from any department are given access to this room.

Surveillance cameras are located on each floor at various locations to keep track of the users and visitors movement in and out of the CHC premises. The recordings are done by the IT department and security measures are taken to prevent any theft of equipments.

3.8. APPLICATION & DATA SECURITY

CHC uses all licensed software with licence keys for all users. Copies of the software are installed on all PC’s. No user is allowed to download or install any software from the Internet. If any user is caught downloading and installing software from the Internet, strict actions are taken. The IT department is responsible for installing, updating and upgrading software on all PC’s and personal laptops.

Users are requested to save their work-related data on their desktops and a back-up of all data are taken every two weeks or once in a month. Users are not allowed to store personal information on their systems. They are not even allowed to bring removable media like CD's, external hard drives and flash drives to CHC.

3.9. DATA MANAGEMENT

Using the *Active Directory Domain Services*, data on the network are centrally managed by the IT administrator. File access levels and permissions are set for each user on the network using *Active Directory Rights Management Services*. Users are given permission to access only those data they have been granted access. If they require access to other specific data, they are required to speak with their respective head doctor as to why they require access to that data.

3.10. REMOTE SUPPORT SERVICES

If any user is facing problem with his/her PC, desktop support is provided by the IT support staff 24/7 using Windows Server 2008's *Remote Desktop Services*. Remote desktop support is also provided to the remote users of CHC who are the Board of Directors, members of senior management and doctors of each department. Since CHC is planning to expand, the remote users of CHC often travel for business purposes and require access to the CHC network.

CHC uses a Virtual Private Network (VPN) and a blackboard academic suite for their remote users and medical interns respectively. Using this, remote users can access data even outside CHC premises. CHC finds the blackboard academic suite very useful for their academic interns as the students can access their training lectures at their homes.

3.11. IT TRAINING FOR USERS

Training sessions are conducted on Fridays and Saturdays in the research centre for those users who are new to using certain medical software. In addition to this, IT training sessions are conducted every month for all users including medical interns where they are required to know about the IT policy and procedures of the organisation, network usage rules and regulations and other IT related factors, and furthermore, medical interns are given full training of medical software. A survey conducted by CHC for its employees have shown that majority of the CHC medical staffs are happy with the IT training held every month. The staffs can use the medical software provided by Cerner and Meditech easily without any help.

3.12. DRAWBACKS OF CURRENT NETWORK

The current network being used in CHC is the client server network. The existing network has got around many client PC's and servers like application, database, web, print, PABX and Exchange Servers. Each client is a PC consisting of monitor or desktop, keyboard, mouse and CPU. Dell, HP and Acer PC's are being used by clients and the servers are IBM and Dell.

The current network of CHC has the following drawbacks:

- The traffic on the current client server network has become so congested. Due to the large number of employees sending requests to the server simultaneously, the server has become too slow to process the clients' requests. Server performance is very slow during the peak morning hours.

- The individual PCs have the required software installed on them. If the medical staffs require new software, the IT administrator has often found it difficult to install that software by going to each individual PC and installing it.

- Server overload and failure has been a common issue faced by CHC. Due to large amount of data stored in the database server, the server has become too overloaded. CHC has always complained that their staffs cannot access or log on to the network and they cannot even access files due to server failure. As a temporary solution, CHC's IT team have asked all staffs to save their work on their own PC's.

- The current network has become so volatile that a chance for a security breach is high. This is solely due to the poor network design and network security procedures. Data distribution across multiple clients and server has increased the risks for security breaches, virus threats and misuse of information. This is because the clients have hard drives built in the CPU's; inserting flash drives and CD's in the USB slots can increase the risks of virus infections. Deploying a thin-client will eradicate security issues as thin-clients do not have hard drives installed in them.

- CHC lacks in a centralised network due to the large number of employees and distribution of data. IT department have found it difficult to manage the large number of clients registered with their network.

- Maintenance and upgrading the network has become a serious hassle for CHC. The IT department has found it difficult to ensure the efficient operation of the network. Upgrading the servers, memory and external hard drives of both the servers and clients has become difficult.

- CHC will be recruiting more staffs during the end of this year. Buying new PC's, additional server and other networking equipments has become too expensive for CHC. Studies conducted by CHC has shown that majority of their expenses was spent for the network maintenance and upgrades.

CHAPTER 4. REQUIREMENT ANALYSIS

In order to design and build the new network, it is necessary to collect the network requirements from the stakeholders i.e., the users of the hospital, clinics and research centre who will be using the network on a daily basis. These users will include the board of directors, senior management members, doctors, nurses, x-ray and lab technicians, biomedical engineers, medical interns, non-medical and the IT staffs. The new network will then serve as a fully functional, integrated, highly secure and reliable network to all the users. It will also serve as a VPN to the remote users of the organisation.

When collecting the requirements for the network, the cost of all the equipments going to be used in the network must be taken into consideration. CHC has specifically mentioned that it requires the thin-client network to be designed and build in a cost-effective way. The reason is because the current network being used is causing the organisation, especially the hospital, to cope with the maintenance and upgrading costs.

4.1. ORGANISATION NEEDS OF THE NETWORK

The following are the technical requirements of CHC:

- PC's or desktops, Servers and personal laptops
- Wireless sensor and surveillance camera for Hospital and Clinic security
- Data backup and recovery, Active Directory, Email, Fax, File Services
- Tablet PC's for doctors and nurses for ease of work
- IP telephony, Wi-Fi on all floors
- Multicast enabled network which can support both audio and video
- Applications like Oracle, SQL Server and Cerner Millennium healthcare solution being currently provided at CHC
- Virtual Private Network (VPN) so that medical staffs (especially doctors), directors and senior management can access data even outside the CHC vicinity.
- The network must support secure transportation of data like basic images (X-Ray etc), VoIP and electronic health records

4.2. BUSINESS REQUIREMENTS

The most important business requirement pointed out by CHC is that it requires a new network which is very secure and reliable so that organisation's confidential details, employee details and patient records cannot be accessed by any outsider other than the person(s) who are given authorisation to access those data. The new network must also be available at all times so that the doctors can access patient records even outside the CHC vicinity. They require a network which is not expensive enough to maintain and can reduce the overall costs associated with the network.

For the IT department, the technical IT staffs requires a network by which they can access all users desktops, provide remote desktop support, monitor the activities of the desktop and perform overall software updates and upgrades rather than having the need to performing the updates on each system.

Apart from the above mentioned requirements, there are other requirements that CHC has addressed which are:

- **Security:** The new network must have a router with firewall installed as the organisation is facing virus threats. If any user's desktop is having a virus, then that virus spreads to all PC's on the network mainly through e-mails and removable media like flash drives and CD's. This makes it difficult for the IT team to go to each system, delete the virus and ensure that all the data are safe. In addition to this, the network has become highly unstable that any hacker can breach into the existing network.

- **Licensed software:** The medical organisation uses licensed software for their existing network and purchasing a licence key for all the PC's on the network has become a hassle. So they require a network which can limit the need to buy more licensed software.

- **Easy access:** There are occasions when the medical staffs of the organisation needs to access their work data off-site. Doctors, nurses and medical interns move around the hospital and clinics daily and it is not possible for them to carry around their PC's to check the health condition of their patients. Since the organisation is expanding its business to other places, the board of directors and members of senior management who often travel outside the country requires the CHC network to be accessed remotely.

- **Environment:** The current network is old and dissipates a lot of heat from the CPU's fans. This heat is causing airborne diseases and health hazards which can affect the health condition of the patients in CHC. Therefore, CHC requires a network which can consume less AC/DC power and dissipate less heat from the systems.

- **Cost:** The overall cost to maintain the current network of CHC is quite high and it's becoming difficult for CHC to cope with these costs. They require a network which can cut down maintenance costs, upgrading costs and costs associated with buying new medical equipments, hardware, licensed software and new desktops for new medical staffs.

- **Entertainment**: CHC requires a network by which their patients admitted in the hospital can watch TV, browse the internet and keep in touch with their family with minimal amount of hardware.

When designing a network for any organisation, it is important to know the users requirement as they will be the ones using the network on a full-time basis. The table below shows the users requirements of CHC:

CATEGORY	USERS	USER REQUIREMENTS	IT REQUIREMENTS
Office Users	All medical & non-medical staffs, medical interns	• Access to all types of applications • Ability to run many applications locally • Flexibility for medical staffs to access medical records even when they move around	• Data protection, security and fast network • Flexibility to move users from one PC to another without any hassle.
Mobile/Off-site Users	Medical sales representatives	• Access data and applications from anywhere	• Provide a secure Virtual Private Network (VPN) , data protection • Full desktop environment
Remote Users	BOD's, members of senior management, doctors.	• Remote access to data and applications	• Provide a secure VPN, data protection and access to network.
Home Users	Medical interns	• Remote access blackboard suite for lectures and other study materials	• Provide a secure VPN, data protection and access to network.

Table 4.2 User Requirements for the network

The above table has split the users of CHC into different categories depending on their mobility. Office users are the full time on-site staffs like medical, non-medical and medical interns. Mobile users are the medical sales representatives who travel on a day-to-day basis for their work and require access to a VPN anywhere. Remote users are the BOD's and senior management who often travel abroad or other places for business purposes especially since CHC is expanding to other countries. Home users are typically meant for the medical interns who wish to access CHC's VPN for lecture notes and other study materials. Keeping the user requirements in mind, the IT department requires a secure VPN by which both their on-site and off-site users can access the network no matter wherever they are. The VPN must be secure, fast and a reliable one so that no information is leaked to the outside world.

4.3. THIN-CLIENT REQUIREMENTS

Before implementing thin-client network, it is necessary to clearly understand the user's and network requirements of healthcare organisation. Below is the list of requirements for a thin-client network and each of these requirements are mandatory and must be met:

4.3.1. BUYING THE SERVER

The most important point to be kept in mind for a thin-client network is buying the server to support thin-client network. There are many types of server like Database Server, Application Server, and Exchange Server etc. But choosing these servers to perform powerfully, efficiently and reliably for a high-scale network and large organisation is a tedious task. The server must have sufficient amount of RAM to handle the entire user's data. In order to have optimal performance for a thin-client server, it is necessary to know the resources like network and client operating systems, number of client PC's, and what type of applications and servers needs to be used [1].

4.3.2. SESSIONS, ADMINISTRATION AND SECURITY

In a networking environment, a session is the communication between a user and his PC. It must be determined as to how many users will be logging into the network at a particular time and how much of RAM and processing power will be consumed.

Central administration is a crucial factor which involves the IT team administering and monitoring the network at all times. The system and network administrators must decide on the following:

- Will the network and client operating system be efficient enough in terms of performance and administration?
- Access must be granted to users who require access to special software, hardware/medical equipments and data.
- Bandwidth of the network must be properly monitored.

Security is another important factor and the level of security must be determined based on the number of clients using the network, data confidentiality, what kinds of applications are used, etc.

4.3.3. NETWORK INFRASTRUCTURE

Infrastructure of a thin-client network will depend on the following:

- Is VPN required especially for those who wish to access their work data remotely?
- Whether the network requires a wireless LAN or dial-up connection and who will be the service provider?

- Bandwidth required for the network.
- Number of existing servers being used at present. If new additional servers are required, what will be their hardware requirements?

4.3.4. SOFTWARE REQUIREMENTS

- Other than the non-medical applications, do the medical departments like OPD, Cardiology, Pathology, Labs, and Dentistry etc require special software for the respective departments?
- Will these new software be compatible with the servers and user's Operating System?

4.3.5. MEDICAL EQUIPMENTS

Being a medical organisation, the hospital and clinics will require medical equipments like anaesthesia gas monitor, diagnostic monitors, portable patient monitor, microscopes, portable ultrasound machines, CT scanners etc. It must be checked whether these machines will be compatible with the new network.

4.3.6. LICENCE FOR WINDOWS

Windows requires licence for a thin-client network. There are two kinds of licence for every thin-client: [1]

- CAL or Client Access Licence
- TSCAL or Terminal Server Client Access Licence.

4.3.7. TECHNICAL SPECIFICATIONS [10]

- 10/100/1000BaseT NIC cards for the thin-client network. 1000BaseT will be a better choice for CHC's high-scale network. An extra 1000BaseT for the Internet will be benefical.
- 2GB of RAM will be sufficient for the network, one slot kept empty for memory upgrade.
- 500GB of memory for servers plus extra storage space for the users. This storage space will depend on the number of users using the network.

4.3.8. COMMUNICATION PROTOCOLS

In any network, a communication protocol must be set in order for the client to interact with the server to perform its duties. When implementing the thin-client network, this communication protocol must be supported by both the thin-client and the server. Microsoft and Citrix provide communication protocols for thin-client networks. [1]

CHAPTER 5. METHODOLOGICAL APPROACH

There are four different types of thin-client computing which are: *Server-Based Computing*, *OS Streaming*, *Blade PC* and *Desktop Virtualisation*.

The above mentioned thin-client computing types were discussed with CHC and they suggested that virtualised thin-client computing be implemented. And for this reason, ***Desktop Virtualisation*** will be designed and implemented for this project. Desktop Virtualisation is a technology or software where a server can simultaneously run multiple Virtual Machines (VM's) or clients and the VM's share the same amount of server memory, processing power and LAN connection. The advantage of this method is that the Virtual Machines give its users the experience of a normal PC with an OS and applications (Fig 5.1).

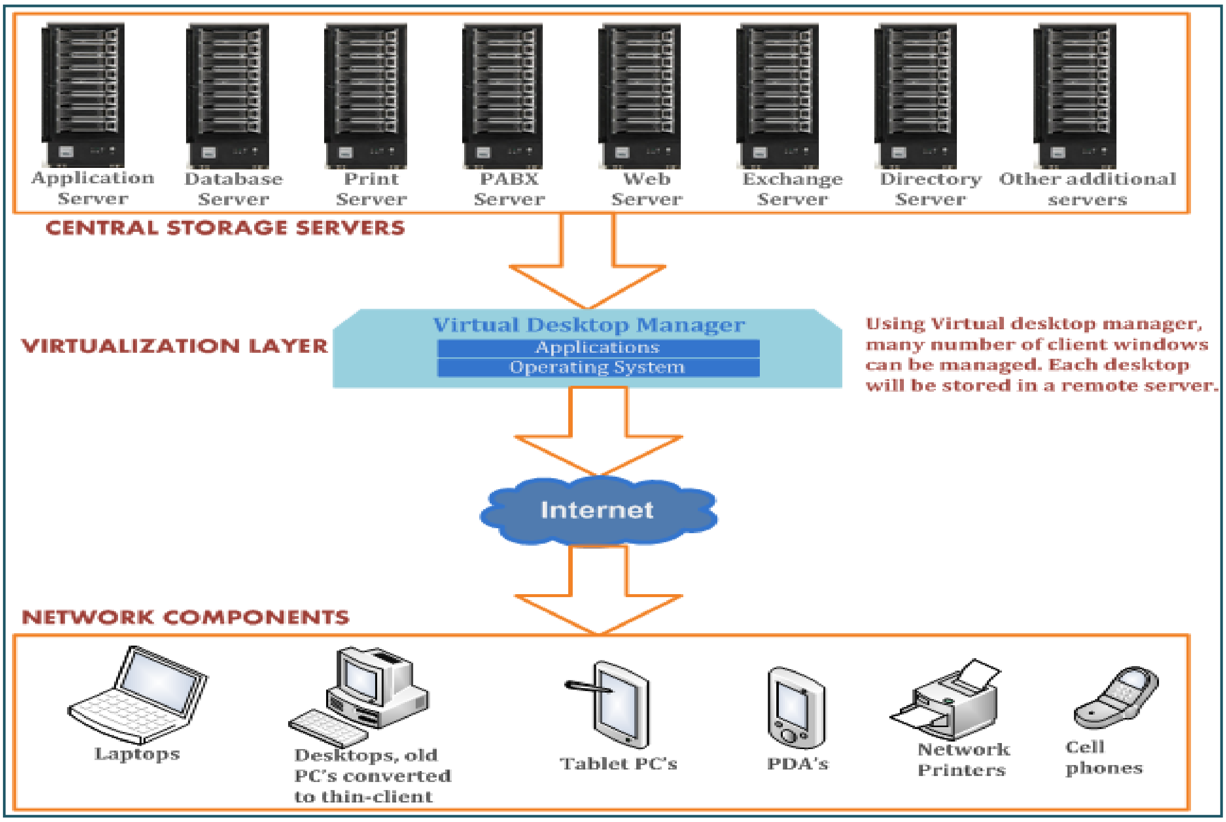

Fig 5.1 Desktop Virtualisation

The above figure gives an idea about how desktop virtualisation works. The different servers used by CHC will be connected to a PC which will be called Virtual Desktop (VD) manager. This PC can be a normal desktop i.e., the current server PC being used in CHC. The VD manager will have the desktop virtualisation management software provided by *VMware*, the best desktop virtualisation solution for all types of organisations. This PC will have the server operating system and other server applications installed. This PC will then control the number of clients registered on the network. Each client's desktop will appear as small windows or icons on the server PC's screen. If the network administrator wishes to view the desktop of another user, he can switch between the small desktop windows appearing on the server PC. The server PC and the clients will be connected to the router and other networking equipments to form the entire network. [11]

Since CHC is a large healthcare organisation, the new network has to be designed on a large-scale basis. Designing a basic thin-client network with servers and thin-client desktops will not solve all the problems. Desktop Virtualisation is the best solution to suit CHC's network and business needs. There are many providers providing desktop virtualisation solutions like Citrix, Sun and VMware; of which *VMware View* will be chosen as the solution provider for CHC.

Brief description about VMware View virtualisation software: VMware is desktop virtualisation software that allows applications to be deployed faster on users 'desktops. It allows desktops to be available to remote users and provides secure remote access to organisation's network. This software provides data protection thereby allowing both remote and non-remote users to access their work securely and transfer information. Users will not have to face technical support for their desktops thereby avoiding the need to call for helpdesk support. Administrators will be able to monitor, control and manage the network; data and applications will be centrally stored in the virtual server thereby avoiding the need to install all applications and back-up data on each client desktop. VMware has two important software that has to be installed on both client and server respectively; installing the client software will be an image file containing the guest and host OS as well as the user's work data. Installing the server software will allow the software to act as an interface between the client desktops and server allowing clients to access applications and data. Using VMware, the total cost of ownership (TCO) will be drastically reduced. This software will give maximum performance, security, reliability, reduced downtime, better desktop and network management. This software will avoid the need of buying new PC hardware as it can work on the present network for a very long time thereby reducing the cost to buy new hardware which is the current problem being faced by CHC. [11]

To implement desktop virtualisation, a well designed plan should be designed and therefore the method of developing a desktop virtualisation for CHC will consist of planning, analysing, design, testing and evaluation stage (Fig 5.2).

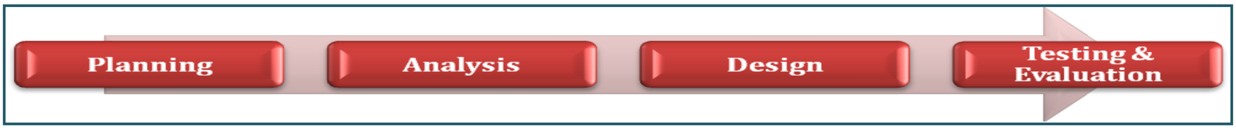

Fig 5.2 Network Design Methodological Phases

Planning – This phase will consist of drawing the network map, where and how the network and medical equipments must be placed.

Analysis – This phase will consist of analysing the network map and rectifying any errors.

Design – This phase will consist of designing the network, replacing incompatible network equipments with compatible ones, converting normal desktops into thin-clients etc.

Testing & Evaluation – After the network has been designed, testing will done to ensure that old problems being faced by the old network has been solved. Any errors found will be solved. Evaluation will be done by allowing the users to work with the new network. A survey or feedback will then be obtained from the users.

Fig 5.3 shows the Gantt chart i.e., a graph showing the timeline for this project. It can be seen from the above figure how the timeline for the project has been divided. The requirement analysis, design, implementation, testing, evaluation and future recommendations have been sub-divided into sub-stages. These are the most important phases of the project and require proper planning and execution. The design and implementation of the project will be done during the month of July. The timeline for the project was kept in mind and time gap for each phase was clearly planned as seen in the figure.

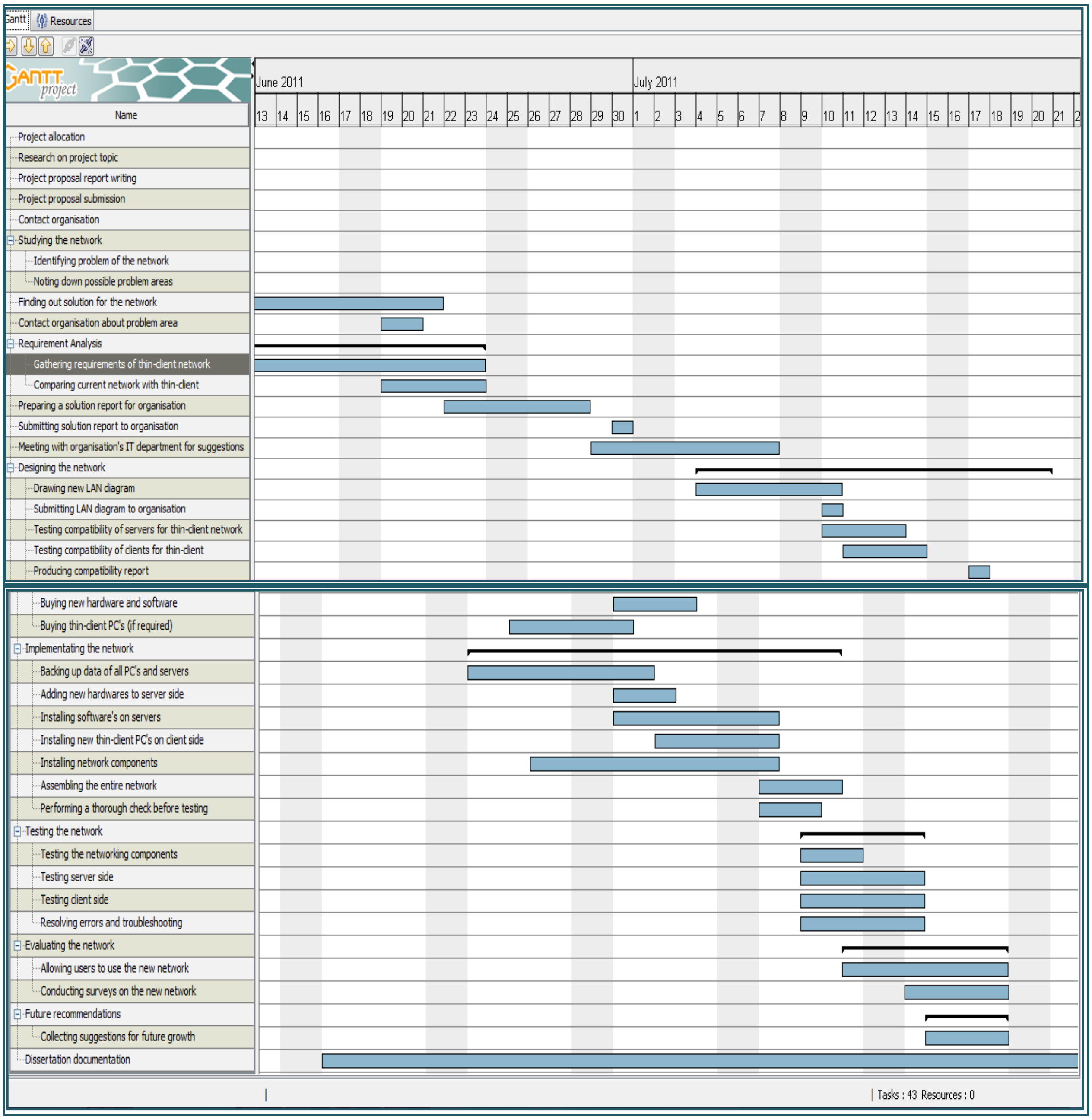

Fig 5.3 Gantt chart

CHAPTER 6. DESIGN OF THE NETWORK

6.1. COMPONENTS OF THE NETWORK

6.1.1. CLIENTS

Tables 6.1.1.1, 6.1.1.2 and 6.1.1.3 shows the existing number of PC's at CHC.

CHC Hospital	
Users	**No. Of PC's**
Number of PC's being used by Board of Directors and members of senior management	20
Number of PC's being used by doctors, nurses, technicians and physicians.	80
Number of PC's being used by pharmacists	7
Number of PC's being used by medical interns	40
Number of PC's being used at the hospital's reception	6
Number of PC's being used by the HR, Finance, Administration, Sales & Marketing department	21
Number of PC's being used the hospital's IT department	14
Number of spare PC's that are in working condition	10
No. of laptops	9
TOTAL NO. OF PC's	**207**

Table 6.1.1.1 Number of PC's at CHC Hospital

The PC's that are being used at CHC are used daily with number of software installed in it. Doctors of CHC hospital have their own individual desktops and they are allowed to bring their personal laptops. Nurses, technicians and physicians do not have individual desktops but share the same PC's. Each user is allocated an individual username and password. CHC has 40 medical interns who do their training at the hospital, clinics and research centre. There are spare desktops at CHC because if a user's desktop failed to function or a new user has joined the network, one of the spare desktop is allocated to him/her.

CHC Family & Dental Clinics	
Users	**No. Of PC's**
Number of PC's being used by doctors, nurses and lab-technicians.	42
Number of PC's being used at the clinics reception	6
Number of PC's being used by the Administration departments	20
Number of PC's being used the hospital's IT departments	14
Number of spare PC's that are in working condition	10
Number of laptops	3
TOTAL NO. OF PC's	**95**

Table 6.1.1.2 Number of PC's at CHC Clinics

The above table shows the number of desktops being used by the CHC family and dental clinics. The number of PC's depicts the total number of desktops being used by both the clinics. Since the number of users at both the clinics are less compared to the hospital and research centre, the number of server and server PC's are limited.

CHC Research Centre	
Users	**No. Of PC's**
Number of PC's being used by doctors, nurses, technicians and physicians.	45
Number of PC's being used by pharmacists	9
Number of PC's being used by medical interns	30
Number of PC's being used at the research centre's reception	5
Number of PC's being used by the HR, Finance, Administration, Sales & Marketing department	30
Number of PC's being used the hospital's IT department	12
Number of spare PC's that are in working condition	20
Number of laptops	6
TOTAL NO. OF PC's	**157**

Table 6.1.1.3 Number of PC's at CHC Research Centre

Thin-client computing does not require replacing the existing desktops (monitor) with new ones. Existing desktops can be converted to a thin-client desktop if it has the necessary requirements for a thin-client desktop. Since most of the desktops being used are HP, Dell and Acer, the same desktops can be used as thin-client desktops. In this way, the cost of buying new desktops will be reduced to a great extent. But for thin-client implementation, all the existing CPU's has to be replaced by thin-client devices. HP provides thin-client Compaq devices which performs well, lightweight and is affordable.

For client side, ***Windows XP Embedded Edition*** will serve as the client OS. This OS is found to be compatible with thin-clients. For laptops, Windows 7 has already been installed which is also found to be compatible with thin-clients.

A compatibility test has been performed to determine whether the existing desktops are capable of being thin-clients. The results of this test have been revealed in Chapter 8 (See Section 8.1.1 pages 54 & 55).

6.1.2. SERVERS

Tables 6.1.2 show the list of servers/ server software being used at the hospital, clinics and research centre. As mentioned earlier, Dell and IBM servers are used at CHC.

CITY HEALTHCARE (CHC)				
Servers/ Server software	**Use**	**Hospital**	**Clinics**	**Research Centre**
Windows Server 2008	Server OS for applications running such as networking, inventory, databases and critical business applications	Yes	Yes	Yes
Cisco IPICS Server Software	Enhances the interoperability of rich media applications. Delivers push-to-talk services across IP networks.	Yes	Yes	Yes
Asterisk IP PABX/PBX Software	This communication server software is capable for IP PBX systems, VOIP and conferencing	Yes	Yes	Yes
Microsoft Exchange Server	Provides email, calendar and contacts on PC, phone and web browsers.	Yes	Yes	Yes
FTPShell Server	Windows FTP server software for enabling secure file downloads and uploads.	Yes	Yes	Yes
Microsoft SharePoint Server 2007	Faster and easier access to information, document management solution	Yes	No	Yes
Microsoft Office Communications Server 2007	Manages audio and video conferencing, instant messaging and VoIP	Yes	No	Yes

Table 6.1.2 Servers being used at CHC

Other than the server software mentioned in the above table, CHC have the following servers:

- Application Server
- Web Server
- Database and Storage Server
- Telnet Server
- Proxy and Web Server
- File, print, scan and fax server.

The existing server operating system Windows Server 2008 will be used in the network and has the following features: backup & recovery, Active Directory services, application server, network load balancing, remote desktop services, print, fax and scan server services.

The above mentioned servers can be used with the thin-client network. Thin-client computing requires the servers to be powerful enough to store rich media applications, data and much more. The application, database, storage and file servers do not have sufficient memory to store the large amount of data CHC users are using. Therefore, one more additional server must be purchased to support desktop virtualisation and this server will act as the virtual server for the new network.

A compatibility test has been conducted to determine whether the servers being used are compatible for thin-client network. The results of this test have been revealed in Chapter 8 (See Section 8.1.2 page 58).

6.1.3. NETWORK COMPONENTS

The following are the networking components being used at CHC and are used according to Cisco network standards:

- Router – Linksys broadband modem with inbuilt firewall and modem
- Gateway - supplied by Etisalat.
- Switches – 16, 24 and 48-port Cisco catalyst switches
- ISDN adapters, Bridges to connect the entire CHC’s network
- Network Interface Cards (NIC’s) installed on all desktops
- Wireless Access Points (WAP’s), Cat 5 fibre optic Ethernet cables and patch panels for the Ethernet cables.

6.2. NETWORK MAP

The main goal behind drawing or developing a network map is to identify the users of the network, identify where the network components must be placed, who will the organisation's ISP and so on. A network map must be divided into two parts: Logical Network Map and a Physical Network Map along with floor plan. Therefore, this section will be divided into two categories.

6.2.1. LOGICAL NETWORK MAP

A logical network map consists of the applications being used by the medical and non-medical staffs, applications used at the servers, shared resources and users of these applications.

MEDICAL DESKTOPS	NON-MEDICAL DESKTOPS
Applications:	**Applications:**
1. All medical applications 2. Blackboard for medical interns 3. MS Office, NOD 32 antivirus, WinRar, Adobe PDF, Nero 4. Internet Explorer 5. Printing software 6. Video conferencing software for the thin-client in conference room.	1. MS Office, NOD 32 antivirus, WinRar, Adobe PDF, Nero 2. Internet Explorer 3. Printing software 4. Accounting software, billing software for pharmacy use, SQL and Oracle 9i. 5. Software for administration, sales and marketing, IT, finance and HR.
Shared Resources:	**Shared Resources:**
1. Network printer, scanner, fax machines, server for storing data.	1. Network printer, scanner, fax machines, server for storing data.
Users: Medical staffs and interns	**Users:** Non-medical staffs.

Fig 6.2.1 Logical Network Diagram of CHC Hospital and Research Centre

6.2.2. PHYSICAL NETWORK MAP

Once the logical network diagram has been discussed and drawn, it is time to draw the physical network map which is the main important thing for developing a new network. The physical network map should include the thin-client desktops, networking components, shared resources like printers, medical equipments, cabling and the servers. It is important that the physical network map contain a floor plan if the organisation for which the network map is being designed has more than one floor. CHC hospital and research centre have two floors - ground floor consisting of the reception, IT department, ICU, nurses station, conference room and server room. The medical departments are split equally in both floors.

Fig 6.2.2.1, 6.2.2.2 and 6.2.2.3 shows the floor plan for CHC hospital, clinics and research centre.

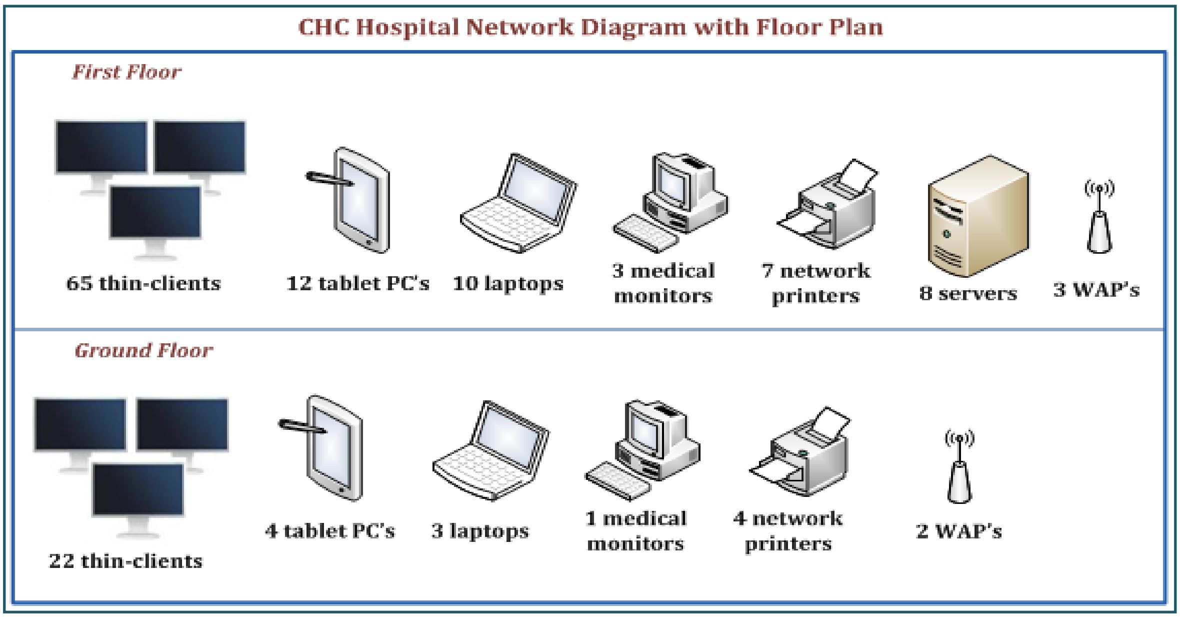

Fig 6.2.2.1 CHC Hospital Network Floor Diagram

The above figure shows the distribution of components on both floors of CHC hospital. This figure is the new network map of CHC hospital with thin-client devices and new servers. As seen in the figure, the servers are placed in the server room on the first floor of the hospital. The thin-clients on the first floor will be used by medical interns also. According to the above figure, the virtualised network will require a router, switches, connectors and hubs to connect all the components together. The cabling system will be reduced so that everyone in the hospital can have access to wireless connection.

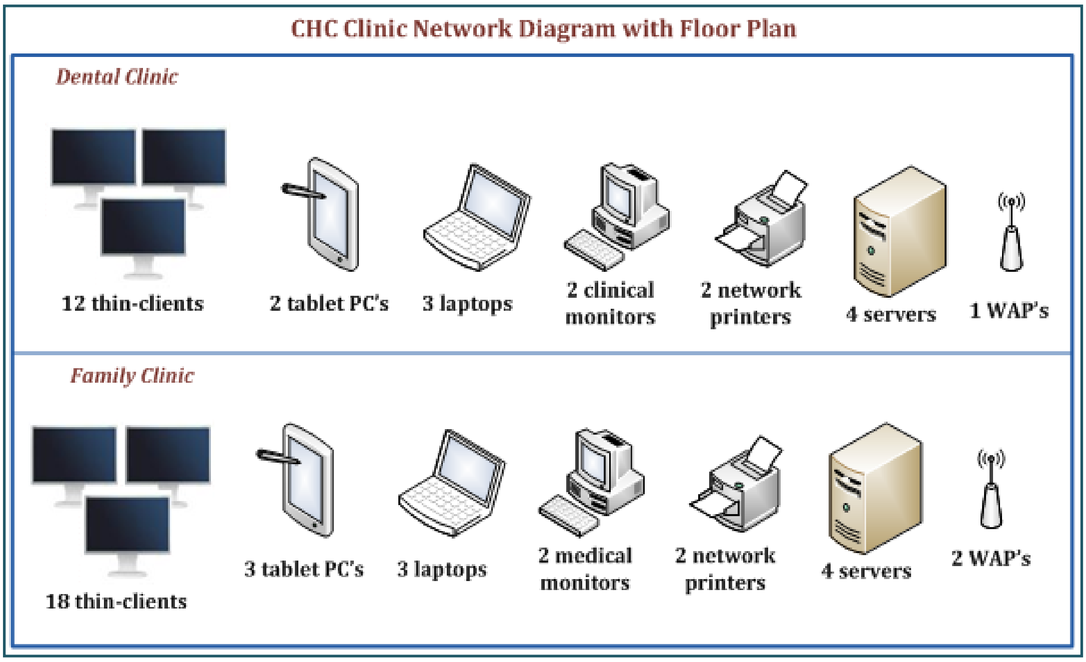

Fig 6.2.2.2 CHC Clinic Network Floor Diagram

The above figure shows the virtualised network diagram of CHC Clinics and how the various components are distributed in both clinics. Tablet PC's were introduced during the beginning of this year as the doctors felt it easy to access their patient records, medical records and other data. The infrastructure of the family clinic is comparatively bigger compared to the dental clinic and this is the reason why 18 thin-clients will be placed.

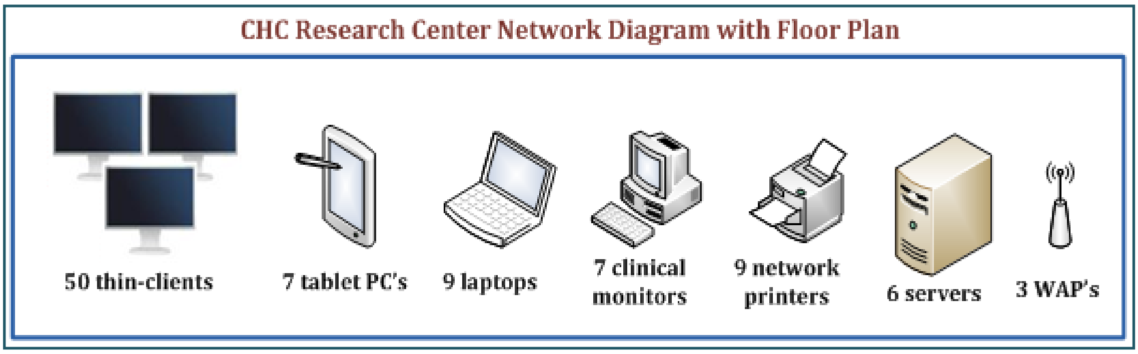

Fig 6.2.2.3 CHC Research Centre Network Floor Diagram

The above figure is the network diagram of the research centre. The research centre will be having one more additional server in their server room and will be used as the central storage server.

Fig 6.2.2.4 shows the detailed network diagram for the virtualised network of CHC hospital.

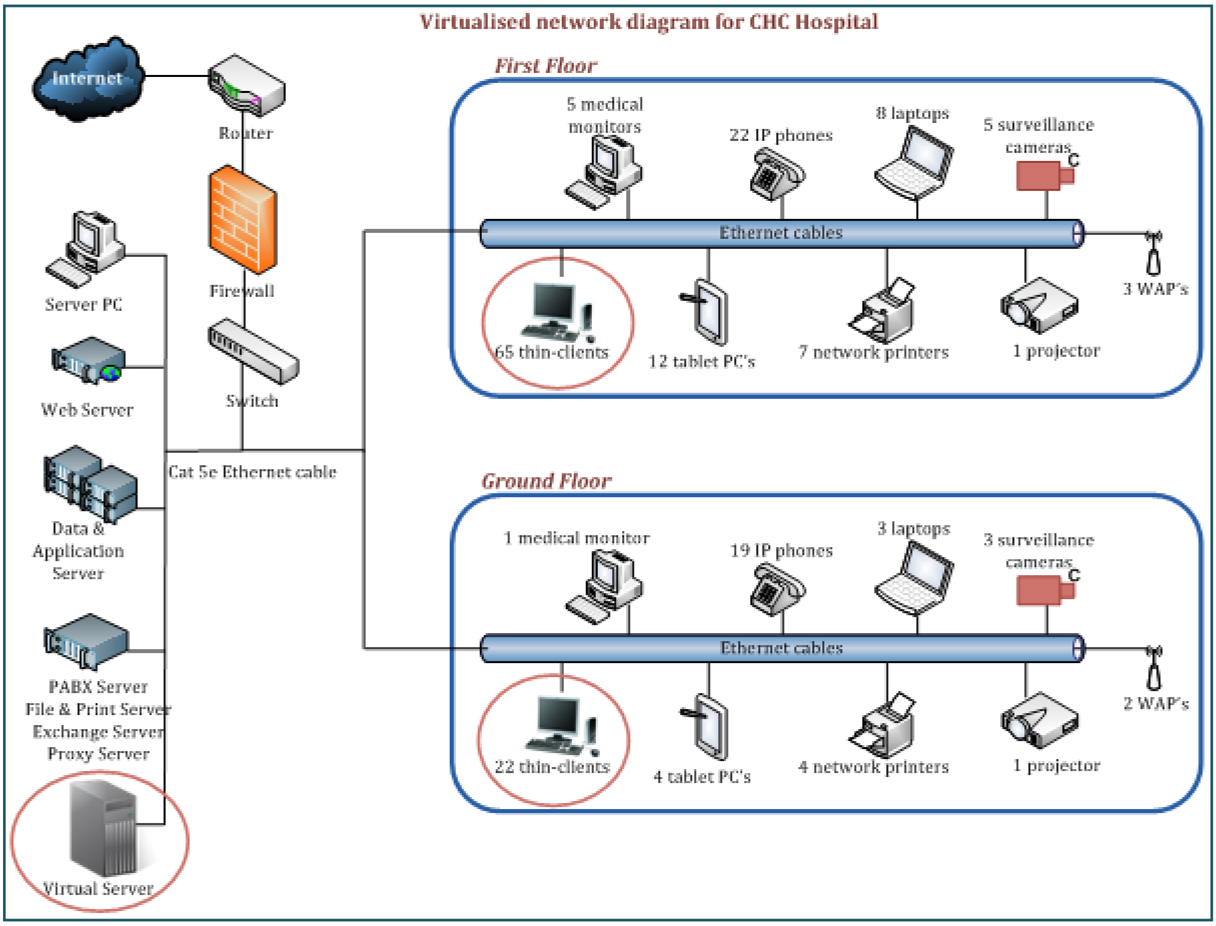

Fig 6.2.2.4 Virtualised LAN diagram for CHC hospital

Cat 5e Ethernet cables are used for connecting the servers to the router and main switch in the Server room. A new virtual server will be added to the network (red circle) and is a powerful storage server to support the virtualised network. HP Compaq thin-clients are the new thin-client devices which can work with the existing user's LCD monitors. All other components are still the same. The virtualised diagram is designed keeping in mind that the arrangement of the components should remain the same as that of the previous network. The new devices and the additional server, denoted by red circle, will form the server and thin-clients of the new network.

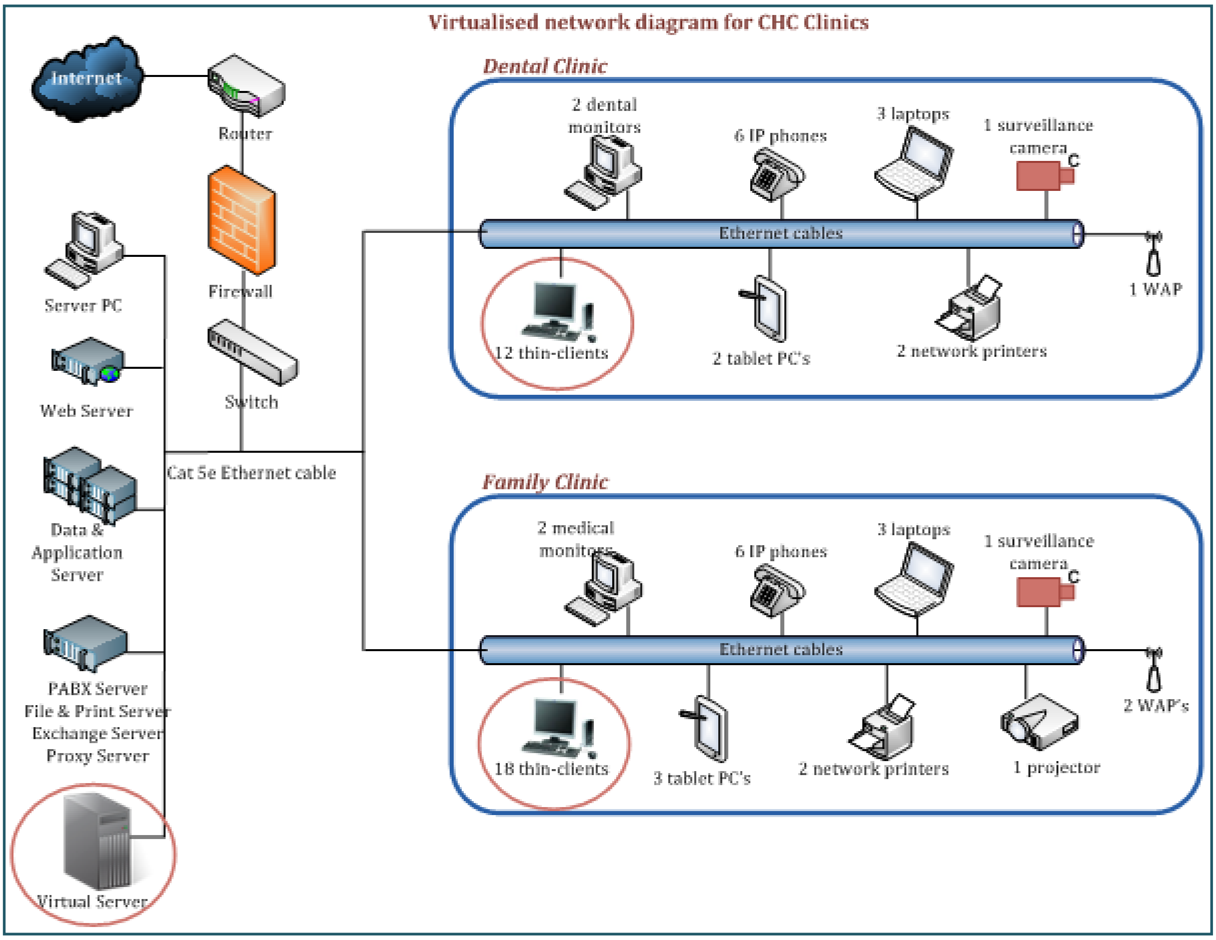

Fig 6.2.2.5 Virtualised LAN diagram for CHC clinics

Fig 6.2.2.5 shows the virtualised LAN diagram for CHC dental and family clinic. It can be seen from the diagram new devices are added to the network denoted by a red circle in the figure. Apart from the existing server being used, a new virtual server will be added which supports virtualised network. This server is capable of storing the entire data and applications of all users and reduces cost to a great extent. New HP thin-clients are added to the network denoted by a red circle. Rest of the components and the arrangement of the network remains the same. The new additional server and thin-clients will form the new thin-client network denoted by a red circle.

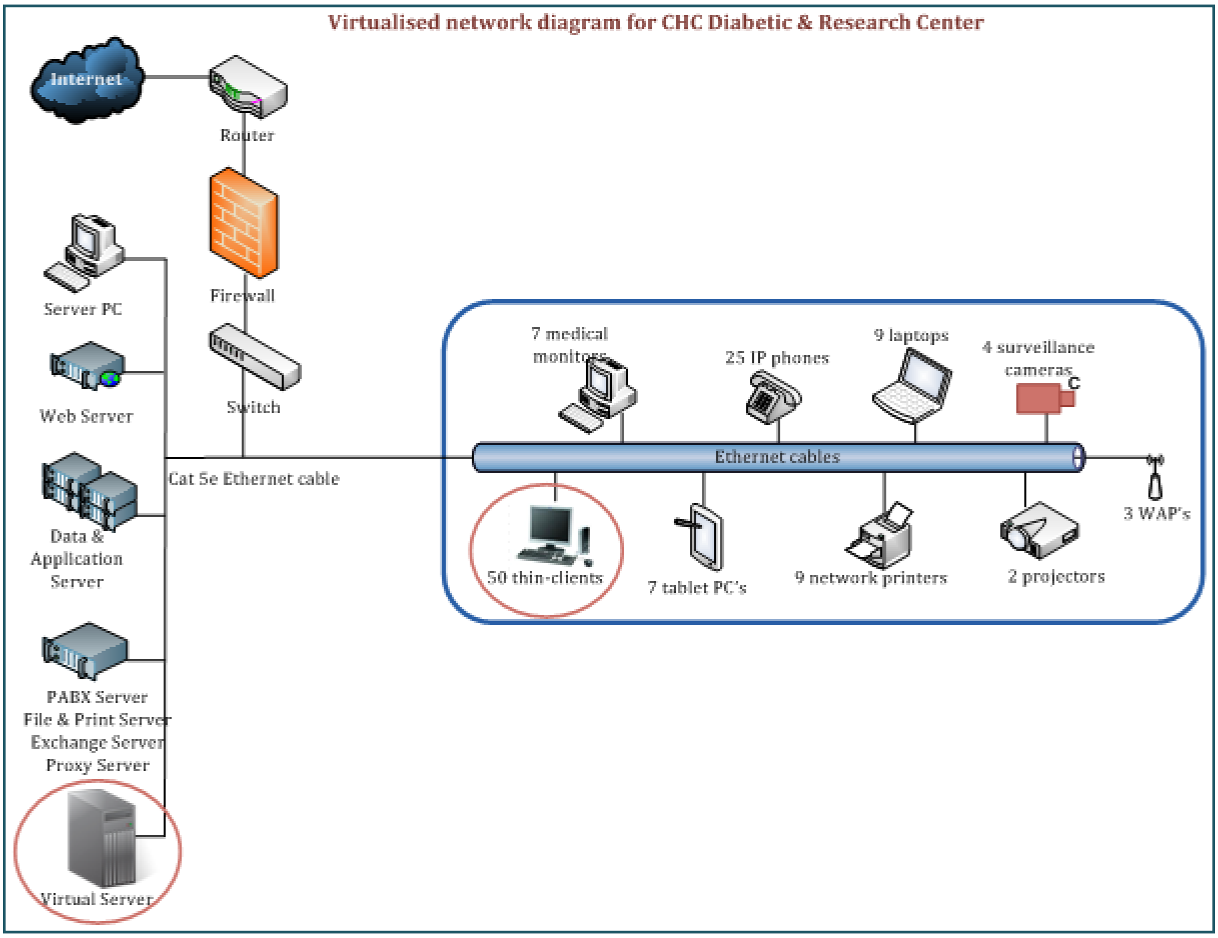

Fig 6.2.2.6 Virtualised LAN diagram for CHC research centre

Fig 6.2.2.6 shows the virtualised LAN diagram for CHC research centre. One new virtual server is added to the new network design as this server is a powerful central storage server capable for virtualisation. New components are added to the network denoted in red circle. Since the research centre was built last year, all the components being used is hardly a year old and is functioning well with the network. The desktops are all found to be compatible with thin-clients; hence there is no need to replace them. Rest of the components and the arrangement of the network are the same. The new thin-clients will also be used by the medical interns.

CHAPTER 7. IMPLEMENTATION

Once the new physical LAN diagram has been designed, the next step is to build the network. The network must be implemented in the same way based on the design and existing arrangement of the network with new components being added. Not following the new LAN diagrams will lead to the network not being implemented well, thereby resulting in the failure of the new network.

Implementing the network will consist of many phases like studying the hardware and software requirements, purchasing new hardware and/or software, purchasing any new networking equipments and servers, installing all the devices together, cabling the devices properly with connectors, installing software and finally testing the network and troubleshooting any errors found. The most important part of implementation is buying the server for the virtualised network. A thorough study on what type of server fits a virtualised environment must be conducted and accordingly the best server must be purchased. This new server must be a powerful enough to store and maintain huge amount of data and applications and must be a secure one to protect the data and applications.

Another important thing to take care during implementation is to set the firewall and other security features for the network. Security updates must be performed when installing the software. Patches must be applied on the OS and software to avoid any kind of security breach or malware. Proper encryption and decryption algorithms must be used in order to ensure safe and secure transfer of information. Licences of all software must be valid and up-to-date.

This chapter will discuss how the network was implemented in stages and what were the difficulties met during implementation. Due to certain reasons, CHC insisted that desktop virtualisation be implemented in the hospital and research centre. Then at a later stage (next year), virtualisation will be implemented in the clinics. So for this project, the implementation is done for the hospital and research centre.

7.1. BACKING-UP DATA

The implementation process started with backing up all the data and applications from all users desktops, laptops and servers. Back-up was done within duration of one week in both the hospital and research centre. Data and applications of all staffs of the hospital and research centre was backed-up during the afternoon hours of working days and on full days of weekends so as not to disrupt the work of any user especially during peak hours. Since CHC backs up data once in two weeks or in a month, the process of backing up was done really fast. CHC has a network attached storage device which they use as an external storage device and hence all the data and applications were backed-up on to this device.

7.2. GATHERING & CONNECTING THE DEVICES

After the data was backed-up, it was time to gather all the components that were essential for implementing the virtualised network. A checklist of all the components required was made to ensure that no components or devices were missing. Following were the components that comprised of the network:

1. Servers: New virtual server and all other existing servers.
    - Server Operating System: Windows Server 2008
    - Memory allocation: 10GB so as to accommodate all the user's desktops.

2. NAS device attached to the virtual server to back data into the server once implementation is done.

3. Networking components: Router, gateway, Cisco catalyst switches, bridges, ISDN adapters, WAP's installed on all floors, Cat 5e Ethernet cables and patch panels

4. Clients: HP thin-clients along with the monitors, mouse, keyboard and NIC installed on each monitor.
    - LCD monitors with 512 MB graphics card and 640x840 resolution
    - Client Operating System: Windows XP Embedded Edition as host OS, Windows 7 as guest OS. Laptops have Windows 7 as host OS.
    - Memory allocation for each user: 1GB memory to support both the guest and host operating systems

5. Network bandwidth of 1GbE (Gigabit Ethernet) for connecting to the Internet.

6. VMware View desktop virtualisation software to manage the many number of thin-client desktops. VMware View software has two main software that has to be installed for successful implementation of thin-client – VMware View Manager and VMware View Client.
    - VMware View Manager installed on the server running Windows Server 2008 to manage the thin-clients.
    - VMware View Client installed on the client side to serve as a virtual machine. Both host and guest OS installed on clients, as one client is being used by more than one user.

Once all the components are in place, they are connected and configured properly so as to avoid errors. The servers and networking devices are connected with the cables and connectors to the switches and router ports. The cabling is done in the server room and all the clients are given wireless connection. Once all the devices and software are connected and installed, the servers and thin-clients are configured properly. Configuring the server side included creating Active Directory accounts for the users, managing user rights, allocating memory space for each user, setting up firewalls for the network and Internet, installing security patches and updates.

Except the server room, all the other desktops of the hospital and research centre were connected wirelessly so to avoid too much of cabling. Each client desktop had the NIC installed by which the network was configured wirelessly. In server room, all servers, networking components and server monitor was connected to each other using Cat 5e cables and all cabling was neatly placed in the wiring closet behind the server cabinet.

7.3. INSTALLING SOFTWARE

On the server side, Operating Systems, network monitoring software, Remote Registry, Active Directory services, medical applications, non-medical applications and other common software were installed with proper updates and licences. VMware View Manager was also installed by which clients can act as virtual machines and perform computational tasks from the server side. On the client side, VMware View Client was installed on each client desktop. The View Client installs a VM image file consisting of the guest and host operating systems and applications used by the user. Software updates were performed and security settings were set up. Host OS is Windows XP Embedded installed as the default OS and guest OS is Windows 7. Virtualised network will now work from virtual server delivering OS, software and screen updates to the users screen. Each delivery of screen updates will be securely transferred from virtual server to user desktop maintaining the confidentiality of information like EMR’s, EHR’s and other data (Fig 7.3).

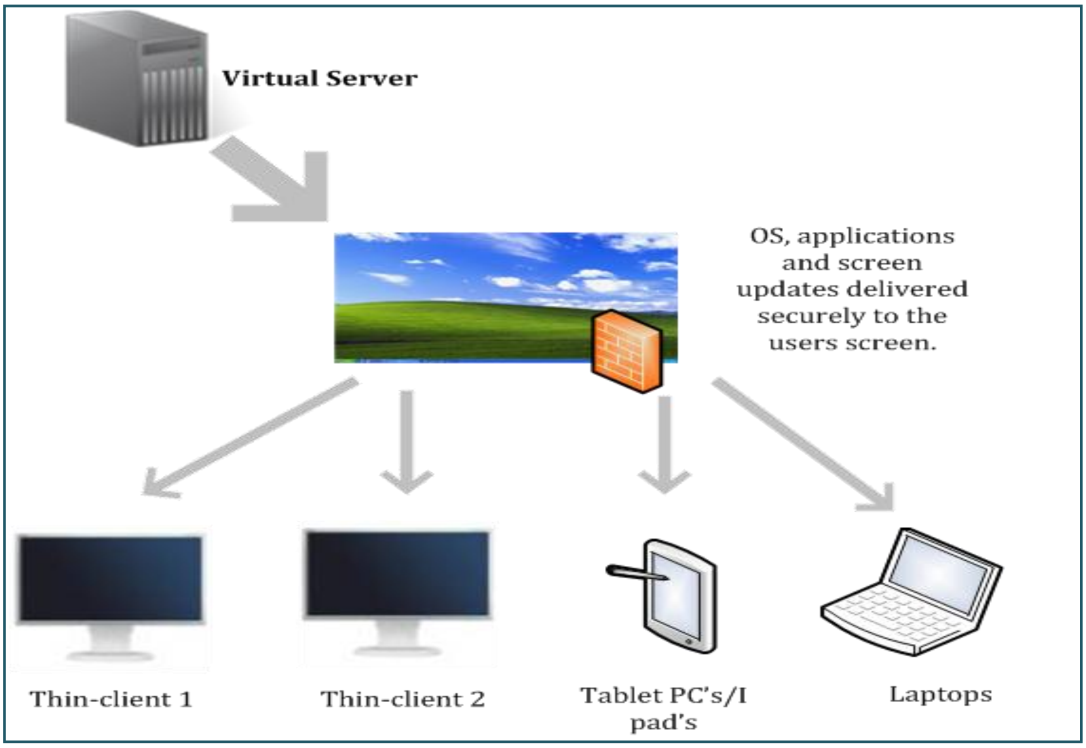

Fig 7.3 Virtual desktop implementation

7.4. CHALLENGES FACED DURING IMPLEMENTATION

The following were the challenges faced during implementation of the thin-client network:

- Installing and configuring thin-client devices on the workstations was difficult especially in the medical training lab as majority of thin-client PC's are located here. For this reason, installing thin-clients in the training lab was done at the end, so that enough time is taken to configure each device.

- Another challenge or difficulty faced was configuring the new server so as to work in coordination with other remaining servers and clients.

- The most challenging task was the installation of VMware software on the clients and server. The software was installed by the system administrator as it requires careful installation by an experienced individual otherwise the software will fail to function or thin-clients will not work as expected.

- Time was a major concern as the implementation stage took plenty of time as it had to be implemented in the hospital and research centre.

CHAPTER 8. TESTING & EVALUATION

This chapter will discuss how the new network was tested based on various factors after the virtualised thin-client network was implemented. After any new network has been implemented in an organisation, it is necessary to perform various tests on the computers, servers and other devices in order to make sure that the design and implementation of the network proved to be a success. Skipping the testing of a new network and allowing the users to directly use the new network after implementation will only result in network errors and failures. Therefore it is always a wise decision to test and evaluate the network before allowing the users to start using the network.

The main goal behind testing the virtualised thin-client network was as follows:

1. To test whether the network had fulfilled the business and users requirements.
2. To test whether all the converted desktops, new desktops, thin-client devices, servers and other hardware and network components worked fine with the virtualised network.
3. To check whether all the software and Operating Systems being used by both client and server were compatible with the new network.
4. To check whether the new network worked efficiently during peak hours.
5. And finally, to troubleshoot any errors found during testing.

Now to test the virtualised thin-client network, it is necessary that the following requirements be met or installed during the time of testing:

1. Workstations: Desktops both new and converted ones.
2. Servers: Application server, Web Server, PABX Server and other servers being used.
3. Networking components: Router with built-in firewall and modem, gateway provided by the Internet Service Provider, switches, Cat 5e Ethernet cables, hubs and bridge.
4. Virtualisation software solution: VMware View and a Host Server.
5. Thin-client devices: HP Compaq thin-clients connected to desktops.
6. Software: VMware View installed on all desktops and servers including host server. Apart from this software, other software must be updated and have licences.
7. Operating System: Make sure the following Operating Systems are installed on client and servers with up-to-date security patches and service packs:
    - Client side: Windows XP Embedded installed as the host OS for all the users of CHC. If doctors, BOD’s or members of senior management wish to bring their laptops, Windows 7 should be the host OS.

- Server side: Windows Server 2008 with latest service pack installed as the server or network operating system.

- Windows 7 installed as the guest OS on virtual machines especially for virtualised network.

8. Active Directory Service, Network Access Control, file sharing, printing and other services for the network.

Once all the requirements are available in hand, it is time to test each and every component of the network starting from the workstation.

8.1. GENERAL TESTING

Various tests were performed on the workstations, servers, biomedical equipments, clinic equipments and other networking components based on factors like performance, reliability, and software and hardware compatibility tests. The tests were performed to ensure that all the problems being faced by the previous network was solved, work-flow of medical staffs and non-medical staffs were running smoothly and network was efficient, reliable and secure. Since the tests had to be performed based on the above mentioned factors, this chapter has been sub-divided into three main sub-sections.

General Test will contain the compatibility tests performed on workstations, servers, software and other devices to check whether they were compatible with the virtualised thin-client network. The different tests performed are discussed as follows.

8.1.1. WORKSTATIONS

Workstations consisted of desktops or thin-clients being currently used by both the medical and non-medical staffs of CHC hospital, clinic and research centre. As mentioned earlier, HP, Dell and Acer desktops are currently being used by all the staffs of CHC. These desktops were tested to check whether they are compatible of being thin-clients. Table 8.1.1.1, 8.1.1.2 and 8.1.1.3 shows the results of the compatibility test performed at CHC hospital, clinics and research centre.

PC Compatibility Test – CHC Hospital	
No. of PC's on which thin-client will be implemented	87
No. of incompatible desktops	11
No. of medical applications to be installed	9
No. of non-medical applications to be installed including OS	22

Table 8.1.1.1 PC Compatibility Test for CHC Hospital

Existing desktops were converted to thin-clients on which virtualisation software is installed and incompatible desktops were replaced by new ones. As mentioned earlier, the number of users to use thin-clients will be more especially for the nurses. All other non-medical staffs and doctors will be allocated a new or converted thin-client.

PC Compatibility Test – CHC Clinics	
No. of PC's on which thin-client will be implemented	30
No. of incompatible desktops	2
No. of medical applications to be installed	5
No. of non-medical applications to be installed including OS	17

Table 8.1.1.2 PC Compatibility Test for CHC Clinics

Only 2 PC's failed to be compatible as thin-clients and new ones are purchased. Existing desktops will be converted to thin-clients using the virtualisation software.

PC Compatibility Test – CHC Research Centre	
No. of PC's on which thin-client will be implemented	50
No. of incompatible desktops	Nil
No. of medical applications to be installed	8
No. of non-medical applications to be installed including OS	21

Table 8.1.1.3 PC Compatibility Test for CHC Research Centre

CHC Research Centre was built last year and hence all the desktops being used were new ones. Results of the compatibility tests (Table 8.1.1.3) showed that all the desktops were capable of being thin-clients and new ones need not have to be purchased.

Functional PC's on which thin-client is implemented had the following technical specifications: Intel Pentium 4 2GHz processors, 1GB RAM for desktops and 2GB RAM for laptops, 8 bits per pixel display, color and brightness control.

8.1.2. SERVERS

The following table shows whether the servers were compatible to work in the new network and whether any additional servers or external hard disks had to be purchased.

Server Compatibility Test	
Total no. of servers at CHC	20
No. of servers that to be replaced by new ones	3
No. of external disk storage devices that had to be purchased for servers	None

Table 8.1.2 Server Compatibility Test

8.1.3. WIRELESS ACCESS POINTS

For any type thin-client network being implemented (Server based or desktop virtualisation), the WAP should have the following features:

- Network Standard: 802.11g
- Bandwidth: 54Mbps

- Wi-Fi Protected Access and MAC address filtering are strongly recommended to be set.

At the CHC hospital and research centre premises, Linksys WAP 200E is the wireless access point installed with 802.11g network standard, MAC address filtering and 54 Mbps bandwidth. This WAP has a frequency of 2.4 GHz that Wi-Fi internet access is available from all corners of the hospital and research centre. Internet connection is available in full range and there is no problem of a slow wireless Internet connection because of the WAP being used. At the CHC clinics, Cisco WAP 200 is the WAP being used with 54 Mbps wireless connection and 802.11g network standard. The wireless access points being used at CHC hospital, clinics and research centre are fully functional. Staffs of CHC have not complained of a poor Internet connection; Wi-Fi is accessible from all the corners of the hospital, clinics and research centre.

8.1.4. TABLET PC'S

As of last year, the doctors of the hospital and research centre had started using Tablet PC's so as to access patient records, health reports and other information. The tablet PC's being used are of Samsung and Toshiba which are fully functional and are capable of being thin-clients.

8.1.5. NETWORK COMPONENTS

The network of CHC hospital, clinics and research centre uses the following components:

- Ethernet cable: Cat 5e cables
- Gateway: Provided by Etisalat, CHC's Internet Service Provider
- Router: Cisco 3800 Series

All the above mentioned components satisfy the requirement for thin-client networks and are fully functional.

8.1.6. BIOMEDICAL EQUIPMENTS

The biomedical equipments like diagnostic monitors, ultrasound, CT scanners and other medical devices were found to be compatible with the virtualised network. No additional medical equipments were purchased.

8.1.7. SOFTWARE

It is necessary to perform a compatibility test for all software to check whether they are compatible with the new network. Table 8.1.7.1 shows the compatibility report performed on the medical applications.

THIN-CLIENT SOFTWARE COMPATIBILITY TEST REPORT – MEDICAL APPLICATIONS				
Application	**Compatible**		**Licence**	**Comments**
	Yes	**No**		
Cerner Millenium PowerChart EMR solution	✓		✓	Application is compatible
Cerner CareAware Multimedia EHR solution for clinicians	✓		✓	Application is compatible
Cerner Image Distribution	✓		✓	Application is compatible
Cerner Critical Care	✓		✓	Application is compatible
Cerner Critical Outcomes	✓		✓	Application is compatible
Meditech Emergency Department (ED) Management Solution.	✓		✓	Application is compatible
PedHeart	✓		✓	Application is compatible
Blackboard Collaborate for medical interns	✓		✓	Application is compatible
Ace-Dental*	✓		✓	The application was found to be compatible but CHC dental clinic wanted to use different dental software.
Birlamedisoft	✓		✓	Application is compatible
PACS (Picture Archiving and Communication System) radiology software	✓		✓	Application is compatible
*Ace-Dental Software is no longer being used at CHC dental clinic. The clinic wanted to use Dentrix Dental Software as the software was easier and yielded more results for the dentists. Dentrix was installed once the virtualised was implemented, tested and was found to be compatible in the virtualised network.				

Table 8.1.7.1 Software Compatibility Test Report for Medical Applications

It can be seen from Table 8.1.7.1 that all the medical applications were found to be compatible with the virtualised environment. The applications were tested first before letting the users use it. Various operations were performed on the applications like report generation to make sure that the medical applications works well in the virtualised network. And it was a success. The dental clinic replaced their dental software with a new one as the dentists wanted result-oriented software. This is reason why they switched to Dentrix dental software.

THIN-CLIENT SOFTWARE COMPATIBLITY TEST REPORT - NON-MEDICAL APPLICATIONS				
Application	**Compatibility**		**Licence**	**Comments**
	Yes	**No**		
Microsoft Office 2007	✓		✓	Application is compatible
SharePoint 2007	✓		✓	Application is compatible
Crystal Reports XI		☒		Application not compatible. Crystal Report 2011 is compatible, hence installed.
Microsoft SQL Server 2008, Oracle 9i	✓		✓	Applications are compatible
OpManager network monitoring software	✓		✓	Application is compatible
NOD 32 and Norton antivirus	✓		✓	Applications are compatible
Nero, Raxco, Adobe Reader, Nitro PDF, WinRar, Tally 9	✓		✓	Applications are compatible
Webex video conference software	✓		✓	Application is compatible

Table 8.1.7.2 Software Compatibility Test Report for Non-Medical Applications

It can be seen from Table 8.1.7.2 that most of the non-medical applications except for the Crystal Reports software were found compatible with the virtualised environment. Crystal Reports XI version was being used at CHC, but was not found to work with the virtualised network. Crystal Report 2011 is the latest edition that works with the new network. Hence, the previous version of Crystal Reports was replaced with the 2011 version.

THIN-CLIENT SOFTWARE COMPATIBLITY TEST REPORT - OPERATING SYSTEMS				
Applications	**Compatibility**		**Licence**	**Comments**
	Yes	**No**		
Windows Server 2008	✓		✓	Server OS is compatible
Windows XP Embedded	✓		✓	Client OS is compatible
Windows 7	✓		✓	Client OS is compatible

Table 8.1.7.3 Software Compatibility Test Report for Operating Systems

It was decided that when the new network will be implemented, Windows XP Embedded will be used as the Operating System for the clients because this OS is compatible with thin-clients. And hence, during implementation, all the current OS were removed completely from all the desktops of CHC. Once done, Windows XP Embedded was installed. The server OS Windows Server 2008 was found to be compatible and is being used as the server OS. Windows 7 is found to be compatible with thin-client and is being used as the operating system for the laptops.

THIN-CLIENT SOFTWARE COMPATIBLITY TEST REPORT - WEB BROWSERS			
Application	**Compatibility**		**Comments**
	Yes	**No**	
Internet Explorer (default web browser)	✓		This web browser was found to be compatible.
Firefox		☒	This web browser is not compatible so was uninstalled.
Google Chrome		☒	This web browser is not compatible so was uninstalled.

Table 8.1.7.4 Software Compatibility Test Report for Web Browsers

After installing Firefox and Google Chrome on the system and checking whether they would work with the virtualised network, it was found that these two web browsers did not work with the new network. Internet Explorer, initially used as the default web browser, is chosen as the web browser for thin-client network.

8.2. PERFORMANCE TESTING

For virtualised network to function and perform well, the servers must be powerful enough to support the number of desktops registered in the network. The number of desktops that a server can support depends on the following hardware characteristics: processor type, amount of memory and hard disk space (minimum 900GB), network and storage configuration, remote protocol used, applications used, frequency of access for application and so on. Two types of tests were performed on the network: a *Light Work Test* and a *Heavy Work Test*.

8.2.1. LIGHT WORK TEST

Light work test was designed to test the performance of the virtualised network based on the computational tasks performed by the clerical users like administrative staffs, sales and marketing staffs, finance staffs, billing and order entry for medicines. These staffs do not use rich media applications; instead they mainly use applications for medicine order processing in pharmacies, accounting tasks, HR tasks, sales and marketing tasks and so on.

The steps for performing this test consisted of the following:

(i) Log on to the user's system (virtual machine) and enter username and password. Once entered, the user credentials will be matched with the Active Directory user credentials to check for user authentication.

(ii) Once authenticated, the following tasks were performed:

a. Start Internet Explorer and load web pages with heavy graphics and light graphics. Once the pages are loaded, close it.

Result: The web pages http://www.med-ed.virginia.edu/courses/rad/ (radiology tutorial website) [29] and http://www.vmware.com/ (Virtualisation website) [11] were opened on separate pages. This step was performed to ensure that the websites were being displayed properly without any errors on a virtualised network.

b. Open Crystal Reports 2011 and perform some computational tasks. Close the application.

c. Open Tally accounting software and perform some accounting tasks. Close the application.

The following tasks were performed and it was found that the applications worked well in the virtualised environment. Tally accounting software took time to load in the previous network, but with the new network the software took very less time to load.

8.2.2. HEAVY WORK TEST

Heavy work test was performed to test the functionality of the network based on the computational tasks performed by rich-media users like doctors, nurses, physicians, medical interns and other medical staffs. These users frequently use rich-media applications like Cerner PowerChart, Birlamedisoft and other medical applications. The following steps were performed to check whether a medical staff could open these applications at one time:

(i) Log on to the user’s system (virtual machine) and enter username and password. Once entered, the user credentials will be matched with the Active Directory user credentials to check for user authentication.

(ii) Once authenticated, the following tasks were performed:

a. Open Birlamedisoft (X-ray software) and leave the application running.

b. Open Microsoft PowerPoint, load a presentation slide saved on the desktop and browse through them. Close the application.

c. Open Ace-Dental (dental management software) and leave it running.

d. Open Cerner PowerChart, load an existing EMR saved on the desktop, browse through the chart and leave it running.

e. Close the running applications.

f. Open Internet Explorer, load two or three websites of choice and leave it running for some time. Close it.

After the following tasks were performed, it was found that the applications did run well. Birlamedisoft took a little more time to load. But compared to the old network where these medical applications took lot of time to load, the above mentioned applications did not take time to load. The applications loaded really fast except for the X-ray software which loaded quickly only when the other running applications were closed.

The feedback of the above performance tests was obtained from the biomedical and IT support technical staffs that had performed the tests to determine whether the applications, display of web pages and other computational tasks functioned well with the new network. Fig 8.3.2.1 shows the feedback form received from the technical staff.

PERFORMANCE TESTING FEEDBACK FORM

1. How does the thin-client perform during peak hours?

We opened 3 to 4 applications at one time and worked on them. We found out that the applications did not take too much time to load; it just took only a few seconds. While working on the applications, we found out that time was not taken to perform a particular task on the application. Thus, we came to the conclusion that thin-client works fast during peak hours and we can guarantee that our users will not face any slow performance during the running of applications. Our users can leave the applications running on their desktops and attend to their patients.

2. Did any applications run slowly or did any applications fail to work in the thin-client network?

Except for currently used version of Crystal Report (version XI), all the other applications were found to be compatible with the thin-client network. No applications had problem working in the virtualised thin-client network. We are extremely happy that all our applications work well without any performance problem.

3. Does the applications and web pages display well on the thin-client?

Yes, all the applications and web pages display perfectly on the thin-clients. All the rich-media applications especially the x-ray software, EMR and EHR software's and dental software displayed perfectly without any problem. We were worried whether this software's would display well because our doctors and nurses frequently use these software's. But there was no problem at all.

4. How would you rate the performance of the thin-client network? Give your opinion.

On a score of 10, we rate the performance as 8.5. We are extremely happy that all the applications being used works well with the new network. We did not face any slow performance at all. Now, our medical staffs can leave their applications running and spend more time with their patients. We can guarantee our staffs that no performance or failure issues will be faced in the network.

Fig 8.2.2.1 Thin-client performance feedback form

The performance of the virtualised network can be depicted in a graphical representation as seen in Fig 8.2.2.2.

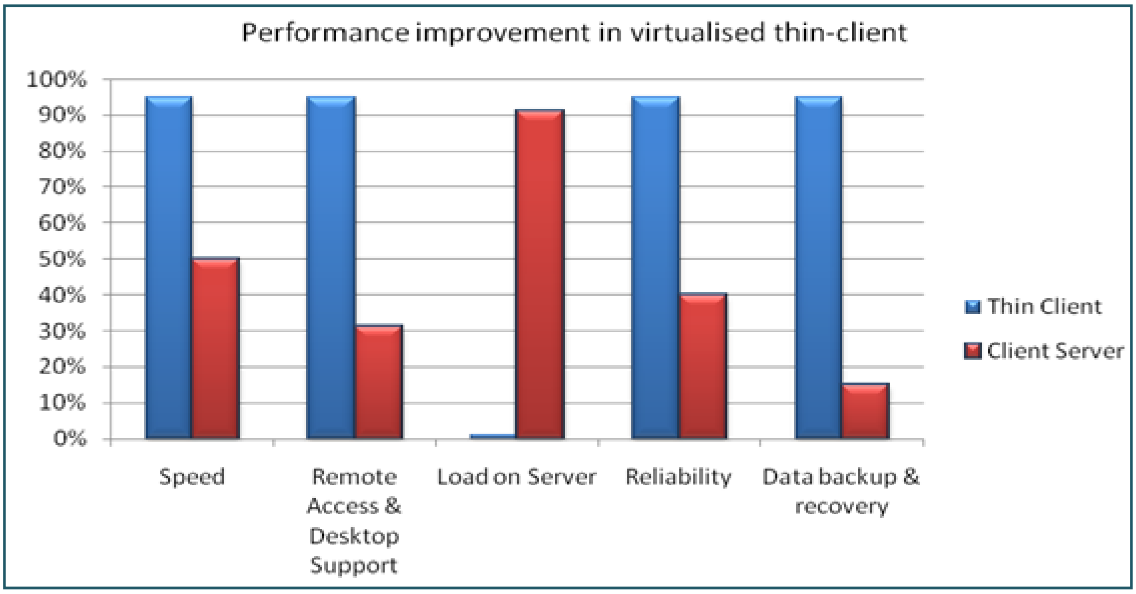

Fig 8.2.2.2 Performance Improvement on virtualised thin-client

From the above graph it can be noticed that there is a big improvement in the performance of the network. With the thin-client network, speed is maximum i.e., users are able to compute their tasks quickly. Remote desktop support is frequently available to all the users. The technical staff can fix any problems on a user's desktop from the server itself. Load on the server had reduced to a great extent because of which the network has become more efficient, reliable and easy to back up data.

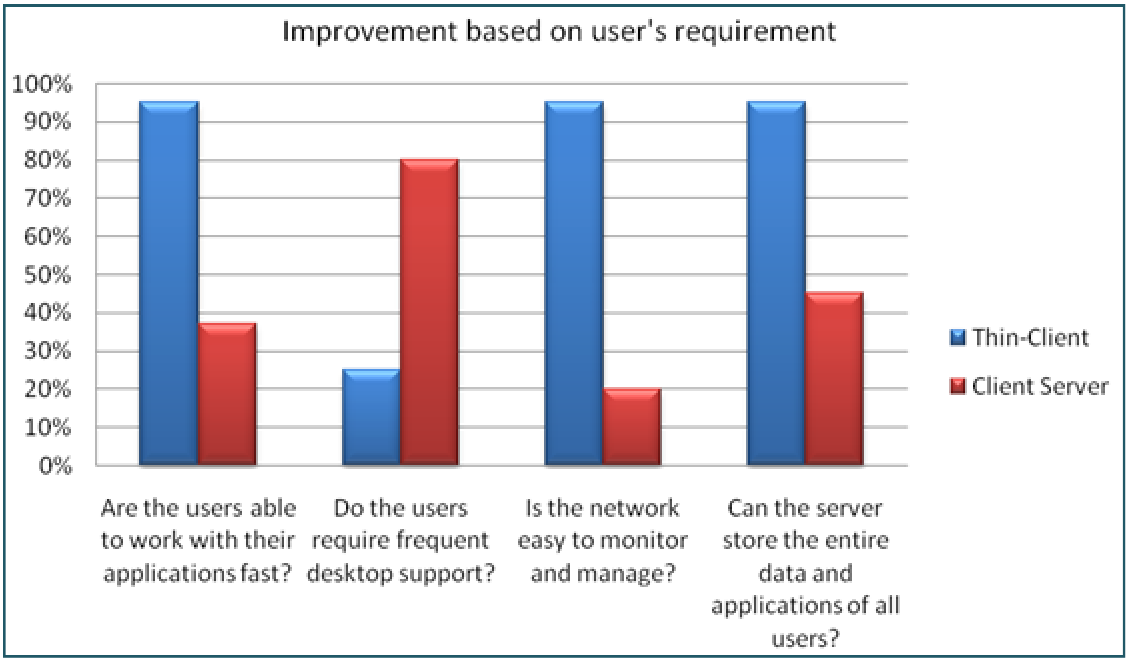

Fig 8.2.2.3 Improvement based on user's requirement

From Fig 8.2.2.3 it can be seen that there is a great improvement on the user's requirement for the new network. Users are now able to work with the applications fast and produce results quickly. The network is easier to monitor, manage and control. Network administrator is able to monitor the network activity of all users and set permissions for access to files, applications and data.

8.3. NETWORK SECURITY TESTING

Security testing was performed to verify that all protection mechanisms were built or set in the network in order to protect the network from unauthorized access and penetration into the network. Security test consisted of password cracking, unauthorised entry into the server and network desktops. It was tested and proved by the technical team that attempts to crack passwords and unauthorised entry into the network to access patient details and other confidential data was all denied. Therefore, the network is now secure.

8.4. POSSIBLE RISKS IDENTIFIED

It is necessary to identify the possible risks that can happen when testing a network after implementation. Many risks or errors can happen which must be taken into consideration and rectified accordingly. When the virtualised network is tested, many risks can happen like applications not working well, error logging into the system, security errors and many more. Table 8.4 shows the possible risks identified along, likelihood or chances for it to occur, impact it can have on the network and the action or solution to be taken during testing (See Appendix A page 83 for MACS Risk Assessment form). The likelihood for risks to happen has been rated on a score of 10.

Risks	Likelihood	Impact	Action/ Solution
Applications fail to work during testing	8	Medium	It must be found out which version of that software is compatible.
Error logging into the system/User authentication failure	5	High	Make sure all users accounts have been created with Active Directory.
Unauthorised access to network	7	High	Apply security patches during implementation. Prepare proper security policies and procedures.
Difficulty adapting to the network	6	Medium	Train all users before they start using the network.
Helpdesk support/ Technical issues	5	Medium	Provide helpdesk support 24/7 for both remote and non-remote users
Problem accessing files and patient records	4	High	Make sure all data has been backed-up during implementation.
Likelihood – Chances for risks to occur *Impact – Impact of the risks on the network* *Action/Solution – Action or solution to be taken immediately*			

Table 8.4 Risk Identification and Solution

8.5. NETWORK EVALUATION

After testing, the network has to be evaluated so as to check and confirm whether the new network was designed and implemented according to the design and requirements of the users and business. A survey was conducted for the IT department to know their feedback about the operation, usage and other technical aspects of the virtualised network. The feedback was given by the network and system administrator who will be responsible for maintaining and administering the virtualised network from now on. Therefore, it is important to know what they think about the new network, has it solved the technical issues faced in the previous network, whether there is any traffic congestion issue, is it now easy to monitor and control the user activities on the network and so on. Fig 8.5.1 shows the feedback received from the network and system administrator.

NETWORK ANALYSIS FEEDBACK

1. Choosing the right thin-client solution & implementing it.

Wide range of thin-client solutions are available in the market today of which desktop virtualisation was the top solution found to be successfully implemented in hospitals worldwide. Implementing desktop virtualisation was a challenge with server storing data and thin-clients acting as "dumb terminals". Choosing VMware desktop virtualisation was the right choice. Deploying it on the server and client was done with careful planning and a lot of time and effort.

2. Server and thin-client connection & configuration.

Installing new server and configuring it with other existing servers was difficult. All devices and servers were connected and neatly arranged in the server room. Configuring servers and thin-clients took great amount of patience and time. Each user was allocated certain amount of memory and network usage. Network bandwidth was chosen as 1GbE to support the number of users using the network.

3. Network documentation report for the virtualised network.

A network documentation report was prepared which consisted of how the network was build, configured and tested according to networking standards. It also consisted of the technical requirements of servers, clients and networking devices. This report will be useful for the technical staffs if any problems occur in the future.

4. Installing software and hardware.

All software's and hardware's were checked for compatibility. Since thin-clients do not store data and applications, all software's and data were installed and backed-up on the server. Software updates and licenses were checked for validity. All necessary hardware (HP thin-clients) was installed on client side.

NETWORK ANALYSIS FEEDBACK (contd.)

5. Applying security patches and service packs.

Latest service packs were installed on the operating systems. Security patches were added with the help of "Windows Update" feature on the server and client operating system.

6. Network testing, monitoring and maintenance.

All software's were tested to check whether they work well and certain tasks were performed. Network traffic was monitored and it came to the conclusion that sometimes bottlenecks can be caused if the traffic on the network is high. A network upgrade will come into effect if more number of users is added to the network. Maintaining the network with the current number of users is not a problem. But if the number of users grow, upgrading the network will be difficult if not planned and implemented well.

7. Data disaster, backup and recovery.

With virtualised network, no data disaster can happen as all the data are centrally stored in a powerful server. And regarding data backup, it is taken once in every month. There is no need to perform backups every now and then. Chances for a data disaster to happen are very rare. In case it happens, data will be recovered soon with the help of the monthly backups being done.

8. Future growth and upgrade.

There are plans for expanding the current network and including more number of users. In that case, we plan to deploy a multi thin-client device by which an approximate of 10 to 20 users can use a single thin-client device. More number of users will require increasing the storage space and avoiding the need to buy additional server.

Fig 8.5.1 Network analysis feedback

After implementing and testing the network, the users must be allowed to use the new network. First, right after testing all the users must be given training in using the new network as some users will find it difficult to adapt to the new networking environment. Training session was conducted for each medical and non-medical department separately, so that enough attention could be given to the users using the new network. User surveys have to be conducted once the users start using the new network on a regular basis. Conducting surveys will help in knowing how the users feel the new network works in terms of performance, are they able to access all kinds of applications or is there any application that does not work according to their requirement, identifying any negative feedback from the users and rectifying them. The feedback obtained from the users will make it clear as to how well has the new network suited the needs of the users, any changes to be done or any kind of technical support required. Fig 8.5.2 shows the feedback obtained from the user survey that was conducted on a score of 10.

NETWORK FUNCTIONALITY QUESTIONNAIRE

QUESTION	RATING	REVIEWS
1. Did you have any difficulty adapting to thin-clients from the traditional PC's	*7*	*There was no difficulty faced as we were given training.*
2. Do all the applications work well?	*10*	*All applications work well with the network. There is no application that did not work.*
3. Any helpdesk support was required at any point?	*9*	*No issues faced as of current.*
4. Did bottleneck or traffic congestion occur during peak hours? Was the network slow at this time?	*8*	*Network is found to be a bit slow especially during morning hours thereby taking time to view, edit and update EMR and EHR's.*
5. Are you able to download or install any application?	*5*	*No download is possible with the new network. Installing an application requires permission from the IT department.*
6. If you are a remote user can you securely access the network even outside the CHC premises? Are you given remote support?	*7*	*At first, when logging as a remote user, user authentication took time. Full time remote desktop support is available.*
7. Give your rating for the overall performance of the network?	*8*	*The network works pretty well. Performance is very good compared to the old network.*

Fig 8.5.2 Network Functionality Questionnaire

Another questionnaire or user survey was conducted to know what the users think about the newly implemented virtualised network. This results obtained from this questionnaire (Fig 8.5.3) will give an idea as to what improvement has a thin-client user received from the virtualised network.

THIN-CLIENT USER QUESTIONNAIRE

QUESTION	RATING (YES/NO)	REVIEWS
1. Were you informed by the management about the change from client-server to thin-client virtualisation?	*Yes*	
2. As a user of thin-client, do you find any advantages of the new network over the old one? If yes, point out the advantages.	*Yes*	*Better reliability, better security, able to access all applications and more productive.*
3. Do you feel the advantages outweigh the client-server network?	*Yes*	
4. Any other problem you faced with the new network?	*No*	

Fig 8.5.3 Thin-Client User Questionnaire

The results of the network evaluation can be graphically represented in the form a chart (Fig 8.5.4) to make it clearer as to how the network has improved (in percentage) based on the user feedbacks received.

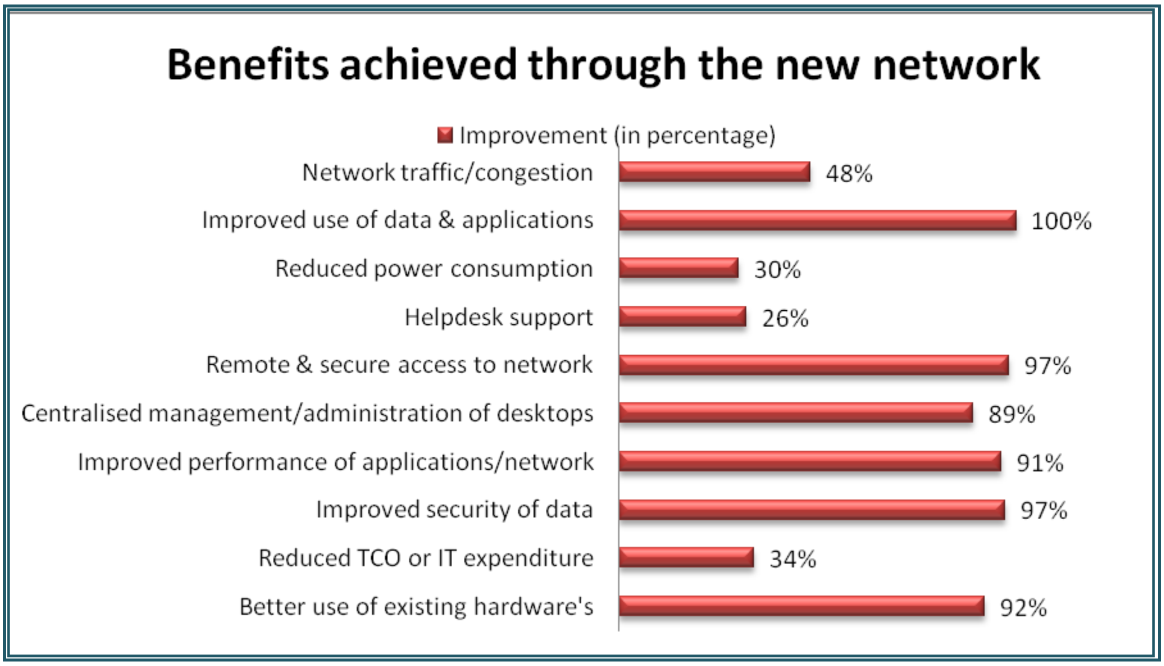

Fig 8.5.4 Evaluation chart for the virtualised network

It can be noticed from the above graph that the new network has improved in many ways. There will be only disadvantage of the new network being faced by users which is the network traffic. Users will experience small network hitches or small bottlenecks in the network during peak hours.

8.6. STRENGTHS OF THE NETWORK

8.6.1. FUNCTIONALITY & PERFORMANCE

1. Performance wise, the new thin-client network is fast. Applications are deployed on the user screen within seconds; this includes the medical applications as well.

2. Except for the two software installed, all other medical and non-medical applications are compatible with the new network. The incompatible software's were replaced by the corresponding compatible version.

3. The network functions smoothly during peak hours except for small hitches. But compared to the old network, all applications are able to function fast and smooth during morning hours thereby making the users effort more productive.

4. All data and applications are centrally stored in the virtual server. Users now don't have the hassle of creating back-up copies of their data on their desktops.

5. Medical staffs are able to leave their applications and work running on their respective desktops and attend to patients.

6. Network and system administrator is now able to centrally manage and monitor the activities of users. Network administration has become an easy task for them.

8.6.2. SECURITY

1. Network has become more secure and less prone to virus attacks. This is because all data are centrally stored in the server and there is no way for any external user to steal data. Moreover, the use of USB devices has been banned for use the CHC staffs. If any user wishes to save data on their removable drives, they will need to approach the IT team.

2. The option for downloading and/or installing files from the Internet has been removed thereby increasing security and avoiding unnecessary bugs and viruses.

3. Patient records and other confidential information can be accessed in a secure way with the implementation of thin-client network. The network and system administrator now maintains a list of who can access what kind of applications.

4. Even remotely accessing the network has become more secure. If a user is remotely accessing the network, his computer credentials are first noted and determined whether the source is a third-party or unauthorised person. If found accessing the network, action is taken against that person.

8.6.3. REMOTE ACCESS & DESKTOP SUPPORT

1. BOD's, members of senior management, doctors and medical sales representatives are now able to securely access the network from any location. After network implementation, the remote users have never complained of remote access failure.

2. Since data and applications are centrally stored on the server, technical support for desktops has been reduced to a great extent. Now there are fewer helpdesk calls. Moreover since users were trained to use the network, they have no problem in using the new network.

8.6.4. USER EXPERIENCE

1. Users now find it easy to work with their applications. Medical staffs have commented that they are able to be more productive nowadays as they their medical applications works fast and produce faster results.

8.7. WEAKNESSES OF THE NETWORK

- Users experience small hitches in the network during peak hours as all users send client requests from client to server. During the peak hours, access to data takes little amount of time. Network administrator has mentioned that compared to the old network, this is not a major concern.

- Though a security policy and manual had been created during network implementation, the IT department must create a document for thin-client network management and maintenance issues if any kind of network management issues is faced.

- Initial cost of project implementation was high due to the addition of a new virtual server and few thin-clients. But the organisation is now able to save a lot from the annual IT expenditure.

8.8. RECOMMENDATIONS & FUTURE WORK

Overall, CHC is satisfied with the performance and improvement of the new network. The issues that they faced in the earlier network are no more. Other than small network hitches, the new network is running smoothly, reliably and securely. Network and system administrators' task of managing the network and solving technical issues has become simple and reduced drastically. Users are happy with the way the new network works; they have received user training for the new network and the network has become more virtualised. They are able to work with their applications well and become more productive.

CHC is planning to expand further; they are planning to recruit more staffs. But with the current network, accommodating or adding new users to the current thin-client network will be a bit risky. A suggestion will be bring in multi thin-client devices which are similar to HP thin-client devices. Multi thin-clients are new in the market and works in the same way as that of a thin-client device. Multi thin-client allows around 10 to 20 users to use the same thin-client device thereby reducing the need to buy additional thin-clients. Moreover there is no need to buy an additional server. Only storage space needs to be increased which can be done on the current virtual server. This recommendation will be taken as future work and will be implemented in the near future.

8.9. TESTING & EVALUATION SUMMARY

It can be concluded that all the software, hardware, servers, networking and biomedical equipments worked well with the new network. Compatibility tests of all software were performed and results of the tests were revealed. Results of the compatibility tests revealed that all software were found to be compatible with the virtualised network except for one (Crystal Reports) which was replaced by the corresponding compatible version. The dental software was replaced by more productive software which worked well with the network. Performance testing was also conducted to check whether the network performed according to the requirements of the users and business. Tests were also performed to check whether all the clients and servers worked efficiently based on the amount of work load given to it. Once all the testing stages were completed, users were given training about the new network.

The virtualised network was then evaluated based on user surveys and questionnaires to know their opinion on the new network. Feedbacks received from the users were positive and any negative feedback was taken into consideration. Therefore, evaluation of the new network revealed that the network performs and works according to the users and business expectations. Possible risks, strengths and weaknesses of the new network were identified and steps are taken to implement a policy manual for network management and maintenance issues.

The future plan of the virtualised network is to bring in multi thin-clients to support more number of users. This multi thin-client will allow around 10 to 20 users to use the only one thin-client rather than having the need to use individual ones. Since multi thin-clients are just new in the market, implementing it will be done in the near future.

CHAPTER 9. PROFESSIONAL, LEGAL AND ETHICAL ISSUES

9.1. PROFESSIONAL ISSUES

Professional issues deals with networking equipments meeting the network standards. Designing the network must follow the policies and procedures of the organisation and the network provider. Cost of the network must be kept in mind.

9.2. LEGAL ISSUES

Every user must have a username and password to gain access to the network. All the software being used must have a licence. User must be given access to only the necessary data and software according to his/her work. No user is allowed to download applications or software from the internet. The IT department must maintain the licence copy and key of all software being used. All hardware, network components, medical equipments and user PC's must have an ID so as to maintain a list of the components being used in the organisation.

9.3. ETHICAL ISSUES

The organisation has requested not to reveal its original name in this project and for this reason a different name has been given to the organisation in this project. Any information relating to the organisation, except software being used will be kept strictly confidential.

In addition to organisation confidentiality, it is most important to secure patient record files, EMR's, employee information and other business information. No such information must be shared to the outside world. Authorised users having access to certain data must keep the information to themselves. Users of the network must keep in mind not to share any patient data, EMR or other business confidential information to the outside world. Such information must always remain within the organisation and not discussed after work hours.

10. CONCLUSION

The main aim of this project was to design and implement a thin-client networking solution for CHC healthcare organisation. There were two objectives in mind: first, study the existing client-server network of the organisation and identify its limitations. Second, perform a thorough research on thin-client computing, its technologies and then choose the best technology for the organisation. Finally, design a thin-client network framework for CHC which will overcome the limitations of the client-server network. A study of the client-server network was done and limitations were found out. The client-server network which consisted of workstations, servers, networking components, biomedical equipments and other shared resources were facing problems like poor network performance, high risks of server failure, remote access and technical support issues. High network traffic was faced during morning hours as this was the time when more number of applications, data and bandwidth were being used. Medical staffs were finding it difficult to work on their medical software delaying patient information displays and results. Moreover maintaining the network had become difficult, thereby resulting in high IT expenditure.

The organisation required a network by which they could access all data and applications securely from their current location. Medical staffs wanted a network by which they can easily access patient records, EMR's and EHR's from their handheld devices. Medical students who work as interns at CHC required a network by which they can access study materials securely even outside the CHC vicinity. They came up with a requirement to solve their network issues either by implementing a new network or upgrade the existing one.

The solution to the problem was implementing thin-client network. Once the limitations of the existing network were identified, a thorough research on thin-client computing and its various technologies were done. Desktop virtualisation emerged as the best thin-client computing solution for CHC. This technology has many advantages over a traditional client-server network: improved security, more reliable and available at all times giving users remote access, reduced IT support costs and support for number of applications and data. The main advantage of virtualisation is that there is no need to replace the entire hardware and equipments with new ones except for an additional server, virtual server, which needs to be purchased so as to support desktop virtualisation. With virtualisation, data and applications are centrally stored in the server and nothing needs to be saved in the client side.

Design and implementation was done with careful planning and time. New physical LAN diagrams were made keeping in mind that the arrangement of the network remains the same. Desktop virtualisation was implemented in stages. Each stage was done on a day-to-day basis across the different departments of CHC instead of doing it at one stretch and thereby affecting the work of users. The most challenging and risky part of the project was the implementation and testing phase. Testing was also done in stages starting from the installing software on both client and servers and configuring devices. Firewall settings, security patches and software updates was done during testing to ensure the security of the network. After testing, an analysis was to done to ensure the following:

- Centralised management of data and applications in a secure way

- Elimination of server failure and malware
- 24/7 remote access and desktop support to both remote and non-remote users
- Medical equipments work well with the network
- Maintain session states of medical staffs so that they can tend more time at patient’s side and begin work from where they had initially started, and
- Reduced TCO IT expenditures.

The final phase of the project was training the users and evaluating the network. Most users face problems adapting to a new networking environment if proper user training it not given. Training the users was done department wise on separate days. After training, the network was evaluated based on feedbacks and questionnaires conducted for the users and technical IT staffs of CHC. The feedback questions were prepared based on the functionality, performance and general use of the applications in the network. Results of the feedback were analysed and reviewed in the feedback forms.

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APPENDICES

Appendix A: MACS Risk Assessment form

MACS Risk Assessment Form (Project)

Student: Sherlin Varghese

Project Title: Virtualisation solution for a healthcare organisation

Supervisor: Ms. Subashini Priya

Risks:

Risk	Present (give details) (tick if present)	Control Measures and/or Protection
Standard Office environment- includes purely software projects	✓	Nothing
Unusual peripherals e.g. Robot, VR helmet, haptic device, etc.	None	Nothing
Unusual Output e.g. Laser, loud noises, flashing lights etc.	None	Nothing
Other risks	None	Nothing

Appendix B: HP thin-client data sheet [31]

HP t5325 Thin Client

Thin computing simplicity and value

Designed as a low cost, high value access appliance, HP 5325 delivers reliable business-class client virtualization.

A new value equation

The HP t5325 can maximize IT budgets with reduced IT management and power costs. Featuring ICA, RDP and View connectivity with basic multimedia & USB redirection, a local web browser, Java and PDF support, the HP t5325 delivers a business-class desktop experience at an affordable price.

Designed for energy efficiency, the small, quiet HP t5325 maximizes space, including flexible VESA mount options.

Fast setup (HP Easy Tools)

The HP Easy Setup Wizard takes the guesswork out of thin client setup by streamlining configuration and management applications into a short series of easy-to-follow and complete screens that help administrators quickly choose the right configurations for their environment.

Administration is simplified further with the HP Easy Update to keep your connectivity software current and HP Easy Config to purose your Hp t5325 as an optimized VDI appliance.

Click and deploy simplicity

HP ThinState allows administrators to capture a configuration profile or complete image from any HP t5325 and save it to a USB key or an HP Automatic Update repository. HP Automatic Update delivers automatic image updates, low bandwidth add-ons (modular software updates) and configuration changes to like devices within a single subnet either in a secure stateless mode or highly reliable persistent mode (recommended.) HP Device Manager simplifies visibility and management for small and large thin client deployments scattered across the multiple subnets and NATed environments.

Trusted partner

Let the HP t5325 help you quickly setup and deploy a powerful computing experience at an affordable price.

HP's proven portfolio of desktop-to-datacenter hardware, software and services will help you create a thin computing solution that improves your IT and user experience. You can also select from a range of HP Care Pack Services to extend your protection beyond the standard warranties[1].

For more information about the HP t5325 Essential Series Thin Client please visit www.hp.com/go/thinclient.

HP t5325 Thin Client

SPECIFICATIONS	
Operating system	HP ThinPro
Client software	Citrix ICA 11 with PNagent/XenDesktop, RDesktop 1.6 (RDP 6 client), Citrix Desktop Appliance (CDA) mode utility, View 4 agent (download 4.5 agent at hp.com), vWorkspace 7 (Quest) and Leostream, local web browser with Java and PDF support
Management and deployment	HP Device Manager agent, HP ThinState and HP Automatic Update for rapid deployment (supports stateless mode or highly reliable persistent mode)
Host environments	Citrix XenApp 4.5, 5.0; Citrix XenDesktop 3, 4; Citrix Presentation Server 4.0, 4.5; Windows Server 2008/2008 R2 Terminal Services, VMware View Manager 4 using RDP and web applications
Multimedia/USB redirection	HP RDP 6 Enhancements for VMware View and Windows Terminal Server connections, Citrix HDX MediaStream and Plug-n-Play components for Citrix connections Note: HP t5325 multimedia support is limited to low screen resolutions, speaker window size and single session only
Processor	Marvell ARM (1.2 GHz)
Memory	512 MB DDR2 RAM
Storage	512 MB Flash
Graphics	XGI VOLARI with 64MB dedicated video RAM; Maximum resolution: 1600x1200; 32 bit color depth; wide screen, & touch screen support
Audio	Internal amplified speaker, 1/8-inch mini-jack, 24-bit stereo
Communications	10/100/1000 Ethernet (actual speeds may vary)
Ports and connectors	4 USB (2 front, 2 rear), DVI-I (VGA adapter included), 10/100/1000 BaseT Ethernet, front audio mic-in and headphone out
Input devices	Standard USB keyboard and 2-button USB optical scroll mouse included
Power supply	36W power supply
Environmental	ENERGY STAR® qualified
Dimensions (HxWxD)	1.24 x 6.3 x 4.72 in (31.5 x 160 x 120 mm)
Weight	Ship Weight: 4.67 lbs. (2.12 kg), Stand-Alone Unit Weight: 1.06 lbs. (0.48 kg)
Warranty	Limited three-year hardware warranty
CarePack Services[1]	9x5 Next-Business-Day Advanced Exchange – 3 Years 9x5 Next-Business-Day On-Site Coverage – 3 Years
Part numbers[2]	VY623AA


HP t5325 Thin Client
Unit can be placed vertically on the workspace, or attach it to a monitor or Integrated Work Center (IWC) with VESA standard mounting
Front audio connections
(4) USB ports; 2 front and 2 back
DIV display connector
10/100/1000 Ethernet RJ-45 connector

HP t5325 Thin Client

1. Service levels and response times for HP Care Pack Services may vary depending on your geographic location. Service starts from date of hardware purchase. Restrictions and limitations apply. HP Care Pack Services extend service contracts beyond the standard warranties. To choose the right level of service for your HP product, use the HP Care Pack Services Lookup Tool at www.hp.com/go/lookuptool. Additional HP Care Pack Services information by product is available at www.hp.com/hps/carepack.
2. Smart Buy or Top value SKU. Available only in certain countries. Check with your HP sales representative or reseller for availability in your country.

Appendix C: Glossary

-A-

Active Directory: Active Directory (AD) from Microsoft is a directory structure used in Windows based computers and servers to store information about networks and domains.

ADSL: Asymmetric Digital Subscriber Line is a type of broadband communication technology used for connecting to the Internet.

Application: Application is computer software designed to help users perform a specific computational task.

Architecture: In networking, architecture is the design of the network.

Authentication: Authentication is the process of verifying that someone is whom they claim to be.

-B-

Bandwidth: In networking, bandwidth refers to the amount of data that can be carried from one point to another in a given time period.

Biomedical: Biomedical or biomedicine is a term that relates to the activities and applications being used in the field of medicine.

Bugs: Bugs is a common term used in software that describes an error, fault or failure in software or system that leads to unexpected results or causing the software or system to behave in unintended ways.

-C-

Cat 5e: Cat 5e is an Ethernet cabling standard that supports high-speed networks.

CPU: Central Processing Unit (CPU) is a part of the computer that performs the basic arithmetic, logical and input/output operations of a computer.

Client: Client is a system or computer that accesses services from the server and depends on the server to avail services.

CAL: Client Access Licence is a licence distributed by software companies to allow users to use software services and connect to the server software.

CCTV: Closed Circuit Television (CCTV), commonly used in surveillance systems, is a system that captures video signals privately.

Client-server: Client-server is networking model where two computers are connected in such a way that one computer (client) sends requests to another computer (server).

Computer: Computer is a machine designed to carry out a sequence of logical operations.

CT scanner: Computed Tomography (CT) scanner is medical equipment used for creating detailed X-Ray images of the body.

-D-

Database: Database is a collection of data that is organised so that it can be easily accessed, managed and updated.

Decryption: Decryption is the process of converting the encrypted data into plain text

Desktop: Desktop is a personal computer intended for use by a single user or multi-user.

Diagnostic monitor: Diagnostic monitor is a medical monitor used for viewing the digital medical images of the body.

Dial-up: Dial-up is an Internet service that allows connectivity to the Internet by telephone lines.

Disk partitioning: Disk partitioning is the act of dividing a logical hard drive into different partitions or hard disks.

Domain: Domain can be a logical sub-network or part of an Internet address.

-E-

EHR: Electronic Health Record (EHR) is the health record of a patient that is shared across hospitals and clinics.

E-mail: Electronic mail (E-mail) is the method of exchanging electronic messages from one person to another or to a number of recipients.

EMR: Electronic Medical Record (EMR) is the medical information of a patient stored electronically.

Encryption: Encryption is the act of converting a plain text into a code.

ERP: Enterprise Resource Planning (ERP) is management software that integrates all the aspects of a business like planning, manufacturing, finance, sales etc.

Ethernet: Ethernet is a physical and data link layer technology used in LAN's.

Exchange Server 2008: Microsoft Exchange is server software that provides e-mails, contacts and calendar on a user's PC, phone or web browser.

-F-

Fibre optic: Fibre optic is a method of transmitting data from one point to another.

-G-

Guest OS: Guest Operating System is an OS installed in a virtual machine along with the default OS.

GPRS: General Packet Radio Service (GPRS) is a packet-based wireless communication service that provides continuous connection to the Internet.

-H-

Hard disk: Hard disk is an external hardware device used for storing data and applications.

Hitches: In networking, hitch refers to slow network performance.

Host OS: Host Operating System is the OS installed as default in a virtual machine.

-I-

Infrastructure: In networking, infrastructure is the interconnected group of computers in a network.

Internet: Internet, also known as 'net', is a combination of many computer networks that allow users to communicate with other computers.

IP: Internet Protocol (IP) is a method by which data is sent from one computer to another on the Internet.

IPTV: Internet Protocol Television (IPTV) is a method of distributing TV content over the Internet.

iPad: Also known as tablet PC; an iPad is a tablet sized hand-held computer that has the same features as that of a PC or laptop.

ISP: Internet Service Provider (ISP) is a company that provides Internet services and access to the Internet.

ISDN: Integrated Services Digital Network (ISDN) is a set of communication standards for digital transmission over ordinary telephone wire as well as other media.

IT: Information Technology (IT) is concerned with the development, installation and implementation of computer systems and applications.

I/O: Input/Output describes any operation, program or device that transfers data to or from the computer.

-L-

LDAP: Lightweight Directory Access Protocol is a set of protocols for accessing information disciplines.

-M-

MAC: Media Access Control (MAC) address is a unique number used by network adapters to identify themselves on a LAN.

Multimedia: Multimedia is the use of computer systems to present text, graphics, animation, audio and video in an integrated way.

-N-

Network: In networking, a computer network is a collection of computers and hardware devices connected together in order to exchange information.

NAS: Network Attached Storage (NAS) is a hard disk storage device that has its own network address and is used to store all the users data and applications.

Node: Node is a connection point or an end point for data transferring. It can also be a computer or a printer capable of data transfer.

-O-

OS: Operating System (OS) is an important software program that runs on any computer. It provides a platform on which other applications can be run.

-P-

PC: A Personal Computer (PC) is a computer used by one or more users and consists of a display/monitor, keyboard, CPU and a mouse.

PABX: Private Automated Branch eXchange (PABX) is a system that allows and controls the sharing of phone lines between telephones and other communication devices. PABX can be a local or computerised PABX system. A local PABX controls the PABX system from a microcomputer like Pentium. A computerised PABX is a system that is centralised around a LAN and does not require connection to the phone network.

-R-

RAM: Random Access Memory (RAM) is a memory device used in computers which can store and access information in any order. In RAM, data can be written to memory and/or read from memory.

ROM: Random Object Memory (ROM) is a built-in computer memory device in which data can only be read but not written to.

Remote access: Remote access is a feature in networking that is used to get access to a computer or network from another computer or a remote location.

Remote registry: Remote registry is a service provided by Microsoft Windows. It allows remote users or IT administrators to modify registry settings of a user's computer, provided the user has the required permission.

Routing: In networking, routing is the process of transferring data packets from source to destination. Routing is usually performed by a router.

-S-

Security patch: A security patch is a small piece of a software or program that is intended to correct vulnerability or errors in any other software or Operating System. In Windows based systems, most security patches, fixes and updates are available in the Windows Update feature of the OS.

SSL: Secure Socket Layer (SSL) is a protocol for managing the security of information exchange on the Internet.

-T-

Terminal: A terminal has many definitions. In computers, terminal is an end-use device (usually a computer, keyboard and mouse) that relies on a powerful computer (server) for its functioning. It's most commonly known as dumb-terminals. In data communication, terminal is a device that terminates one end of a signal.

TSCAL: Terminal Server Client Access Licence (TSCAL) is a licence that allows more number of users to access a Windows server.

Thin-client: A thin-client is a computer that relies on the server to do its work. A thin-client is part of the network and acts like a dummy while the server does all the data processing and updates.

TCO: Total Cost of Ownership (TCO) is a financial term used in many organisations that is designed to help consumers and managers access both direct and indirect costs associated with IT equipments.

-U-

Ultrasound machine: Ultrasound machine is a system used in hospitals and clinics which create images that allows various organs of the body to be examined.

UAC: User Account Control (UAC) is a security component that enables users, both administrators and non-administrators, to perform common tasks without having the need to switch users.

USB: Universal Storage Bus (USB) is a plug-and-play storage device that is used to connect one device to another mainly for transferring data to/from the devices.

-V-

Virtualisation: Virtualisation is the process of creating a virtual version or copy of the Operating System, server, storage device or network components.

Virtual server: A virtual server is a server that is shared by multiple users.

Virus: Virus is a software program that multiplies itself and is capable of causing harm to the system, software, data or other devices.

VDI: Virtual Desktop Infrastructure (VDI) is the practice of deploying a desktop's operating system within a virtual machine running on a centralised server (virtual server).

VM: Virtual Machine (VM) is a program or an operating system that does not exist but is created within an environment.

VMware: VMware is the name of an organisation that provides virtualisation solutions to organisations that are planning to implement thin-client computing. VMware is one of the best companies that provide virtualisation solutions in the market.

VMware View: VMware View is a desktop virtualisation software developed by VMware corporation. This software helps IT staffs of an organisation control desktops and applications, reduce overall IT expenditure and increase data security that centralised management.

VMware View Client: VMware View Client is the virtualisation software installed on all client computers of a network that allows the users to connect from their Windows based OS to remote Windows desktops managed by the VMware View software. This software is installed as an image file from which each user can access and work on his/her data and applications.

VMware View Manager: VMware View Manager is the virtualisation software installed on the central server of the network and enables IT administrators to deploy thousands of individual virtual or client desktops from a single point of control thereby improving management of all desktops.

VPN: A Virtual Private Network (VPN) is a network that uses a public telecommunication network like Internet, to provide the remote users or remote branches of an organisation with secure access to the organisation's network.

-W-

Windows Server 2008: Windows Server 2008 is a server based OS developed by Microsoft for organisations that require their servers to handle shared file/print services, active directory services, network services, terminal services, web services and other essential services for the smooth running of the network.

Windows Registry: Windows Registry is a central storehouse where all settings of the Windows operating system are saved. These settings include hardware configuration, file associations, control panel settings and other important settings.

WAP: Wireless Access Points (WAP's) are configured nodes on a wireless LAN. They act as a central transmitter and receiver by which data can be exchanged wirelessly between two or more devices.

Wi-Fi: Wireless Fidelity (Wi-Fi) refers to the wireless networking technology that allows computers and other devices to communicate with each other over a wireless signal. It describes all network components based on the networking standards 802.11a, 802.11b, 802.11g and 802.11n.

Workstation: A workstation is a computer intended for use by the individuals of an organisation and offices. It is mainly meant for business or professional use and not for homes.