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# Design and Deployment of Local Area Network (LAN)

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**ABSTRACT**

A Local Area Network (LAN) is a computer network within a small geographical area like office buildings, computer lab, school etc. A LAN is made up of interconnected workstations and personal computers which are each capable of accessing/sharing data and devices anywhere on the LAN. Network structure, Network Criteria and Distributed processing are three things we must have in mind when we are discussing networks. The purpose of the network is to design and deploy a Local Area Network and deploy security measures to protect network resources and system services.

***Keywords:*** *Local Area Network, Deployment, Design, Communication, Network*

## 1. INTRODUCTION

A network is defined as two or more computer linked together for the purpose of communication and sharing information and other resources. Most networks are constructed around a cable connection that links the computer. This permits the computer to talk (and listen) through a wire. More recently, a number of wireless solutions have become available. Infrared ports, Bluetooth radio links, and other protocols allow a variety of new devices to link with computer.

In order for a network to function, the network must provide connections, communication and services.

- **CONNECTIONS**: Includes physical (hardware) component like Network Interface Card (NIC) and network cable required to hook a computer to network.
- **COMMUNICATION**: Establish the rules concerning how computer understand each other. Because computers often run different software, to communicate with each other they must speak the same language. Without communications, computers remain isolated.
- **SERVICES**: Defines those things a computer shares with the rest of the network.

**METHODOLOGY**

The designing and installation of computer system network for internet connection was accomplished through the following methods:

- Theory of the project
- Design principle and consideration
- Material selection/procurement
- Consultancy services from expert
- Application of Design principle

**PROJECT MATERIALS**

The various network materials/tools used in the course of the project include:

- Fibre Optic Cable/ Unshielded Twisted Pair Cable
- Rj45 Connector
- Switches
- Routers/Wireless Access Point
- Modem
- Computer Systems/Laptop/Printers

- Network Servers

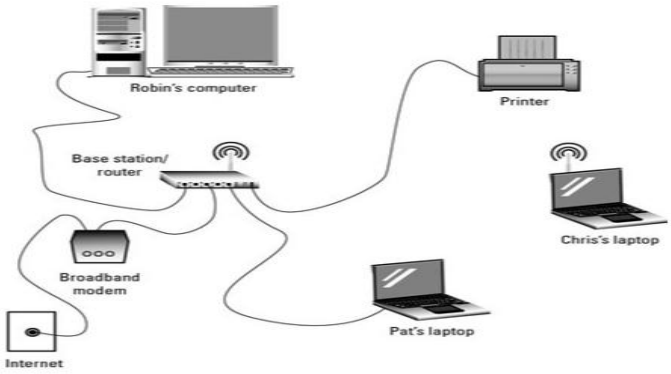


**Fig 1: Linking Up of the Computers to the Network Switch for Network Connection**

## 2. PROJECT PLANNING, DESIGN AND IMPLEMENTATION

### SITE INSPECTION

Site inspection is the bedrock and most crucial stage of this work. It involves visitation and surveying of the area of the proposed project. The result of site inspection is imperative for the following majors.

- Network Topology
- Type of Computer Network
- Network Protocols

### NETWORK TOPOLOGY

Network really has two shapes or two types of topology [1]:

- Physical topology
- Logical topology

The physical and logical topologies are independent of each other. The physical topology refers to the physical layout of the wires where the logical topology refers to how data moves through the network.

### TYPES OF COMPUTER NETWORK

There are two basic types of networks: Wide-Area Network (WAN) and Local Area Networking (LAN).

a) **Local Area Network:** Local area network or LAN network was implemented in the project. It consists of a computer network at an individual office building. A LAN is used to share resources, such as printers etc. LANs can be built with relatively inexpensive hardware, such as hubs, switches, network adapters and Ethernet cables.

b) **Wide Area Network:** Wide area network, or WAN, occupies a very large area, such as an entire country or the entire world. A WAN contains multiple smaller networks, such as LANs or MANs.

### NETWORK PROTOCOLS

A network protocol defines rules and conventions for communication between network devices. Network protocols include mechanisms for devices to identify and make connections with each other, as well as formatting rules that specify how data is packaged into sent and received messages.

### OSI PROTOCOL

OSI protocols are a family of standards for information exchange. These were developed and designed by the International Organization of Standardization (ISO). The ISO model was introduced in 1977 and it is consisted of seven different layers. Because of its technicality and limited features, the model has been seriously criticized.

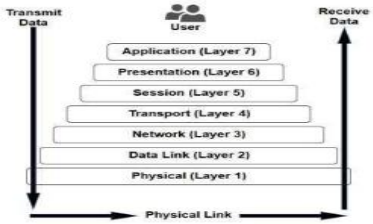


**Fig 4: The 7 Layers of OSI**

**NETWORK ROUTING PROTOCOLS**

Routing protocols are special-purpose protocols designed specifically for use by network routers on the internet. A routing protocol can identify other routers, manage the pathways (called *routes*) between sources and destinations of network messages, and make dynamic routing decisions. Common routing protocols include RIP, RIPV2, EIGRP, OSPF, and BGP. We used Static and EIGRP routing protocols because it is generally accepted.

**MAKING A FAST ETHERNET NETWORK CABLE**

The standard cable used for fast Ethernet networking is called twisted pair cables. It is so called because of the four sets of twisted wires (two in each set) in a standard cable. Each pair is made up of a solid colour wire and a white wire with a small line of the same colour on it. At each end of a cable is connector called an RJ45 connector.

**CATEGORIES FOR ETHERNET CABLES**

A variety of different cables are available for Ethernet and other telecommunications and networking applications. These cables that are described by their different categories, e.g. Cat 5 cables, Cat-6 cables often used. It is recognised by the TIA (telecommunications Industries Association) and they are summarized below:

| CATEGORY | SHIELDING | MAX TRANSMISSION SPEED (AT 100 METERS) | MAX BANDWIDTH |
|---|---|---|---|
| Cat 3 | Unshielded | 10 Mbps | 16 MHz |
| Cat 5 | Unshielded | 10/100 Mbps | 100 MHz |
| Cat 5e | Unshielded | 1000 Mbps / 1 Gbps | 100 MHz |
| Cat 6 | Shielded or Unshielded | 1000 Mbps / 1 Gbps | >250 MHz |
| Cat 6a | Shielded | 10000 Mbps / 10 Gbps | 500 MHz |
| Cat 7 | Shielded | 10000 Mbps / 10 Gbps | 600 MHz |
| Cat 8 | Details to be released later | | |

**Fig 7: Ethernet Cable Performance Summary**

The body placed a standard in networking EIA/TIA. The two wiring standards are known as 568A and 568B. But the one we used to be the 568B standard.

The procedures we took for the crimping of the network cable includes

- Bringing the necessary tools we require, we normally use crimper.
- Stripping the wire, we striped the outer casing from the cable, so as not to affect the network performance and it was about half inch of the casing.
- We untwisted the wires, and then straighten them, arrange the category 5 cable according to the 568B standard and bring them in and tight to each other. If the wires are not of identical length, we use a pair of wire cutters to cut out the excess length to ensure the same length.

**Fig 8: Arranging the Category 5 Cable According to 568B Standard**

- We fixed the RJ45 connector to the end of the cable.
- Then, we insert the cable, the RJ45 connector into the crimping tool and then crimp.

**Fig 9: Crimping Tool (Crimper)**

- The cable is tested by the use of a cable tester. If it brinks light from 1 to 8, it indicates that the LAN cable is functional and can be used.

**Fig 10: Cable Tester**

**IP ADDRESSING**

IP addresses are software or logical addresses that are used to identify a network and sometimes a particular host on a network. It's a 32-bit address.

**CLASSES OF IP ADDRESSING:**

TCP/IP defines five classes of IP addresses; class A B, C, D, and E with a range of valid IP addresses for each of the classes. The value of the first octet determines the class. IP addresses from A, B and C can be used for host addresses while D and E are used for other purposes. The class D shall be used for multicast and class E for experimental purposes.

The system of IP address classes was developed for the purpose of Internet IP addresses assignment. The classes created were based on the network size. For example, for the small number of networks with a very large number of hosts, the Class A was created. The Class C was created for the numerous networks with the small number of hosts.

**Table 2: IP Address Classes**

| CLASS | FIRST OCTET VALUE | SUBNET MASK |
|---|---|---|
| A | 0-27 | 8 |
| B | 128-191 | 16 |
| C | 192-223 | 24 |
| D | 224-239 | - |
| E | 240-255 | - |

- For the IP addresses from Class A, the first 8 bits (the first decimal number) represent the network part, while the remaining 24 bits represent the host part. Therefore, a Class A network mask is defined as 255.0.0.0.
- For Class B, the first 16 bits (the first two numbers) represent the network part, while the remaining 16 bits represent the host part. A Class B network mask is shown as 255.255.0.0.
- For Class C, the first 24 bits represent the network part, while the remaining 8 bits represent the host part. A Class C network mask is shown as 255.255.255.0.

The following figure summarizes the network and host portion of each address class:

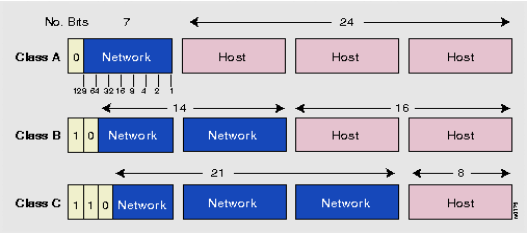


**Fig 11: Network and Host Portion of each Address Class**

Special IP address ranges that are used for special purposes are:

- **0.0.0.0/8** – addresses used to communicate with the current network
- **127.0.0.0/8** – loopback addresses
- **169.254.0.0/16** – link-local addresses (APIPA)

**IP SUBNET ADDRESSING**

All Classes of IP networks can be divided into smaller networks called sub networks (or subnets). Dividing the major class network is called sub netting. Sub netting provides network administrators with several benefits. It provides extra flexibility, security, simplified management, makes more efficient use of network address utilization, and reduce network traffic.

**IP SUBNET MASK**

A subnet address is created by "borrowing" bits from the host field and designating them as the subnet field. The number of borrowed bits is variable and specified by the subnet mask.

The following figure shows how bits are "borrowed" from the host address field to create the subnet address field:

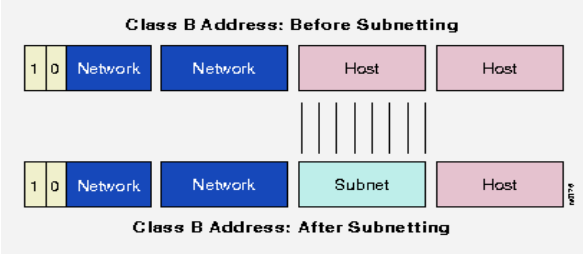


**Fig 12: Sub netting of Class B IP Address**

Subnet masks use the same format and representation technique as network mask format, the subnet mask has binary 1s in all bits specifying the network and sub network fields, and binary 0s in all bits specifying the host field.
The following figure shows a sample subnet mask:

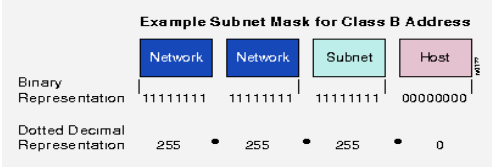


**Fig 13: Subnet Mask of Class B IP Address**

**IP ROUTING**

IP routing is the process of sending packets from a host on one network to another host on a different remote network. This process is usually done by routers. Routers are used to examine the destination IP address of a packet, determine the next-hop address and also forward the packet. Routers use routing tables to determine a next hop address to which the packet should be forwarded.

Routing information is stored in the routing table also called the **Routing Information Base (RIB)**. The RIB consists of routes to destination networks. Each route is a combination of the destination network address, subnet mask and the next hop towards the destination.

**VLAN**

VLANs (Virtual LANs) are logical grouping of devices in the same broadcast domain. VLANs are usually configured on switches by placing some interfaces into one broadcast domain and some interfaces into another. VLANs can be spread across multiple switches, with each VLAN being treated as its own subnet or broadcast domain. This means that frames broadcasted onto the network will be switched only between the ports within the same VLAN.

In the course of our routing sometimes we used Static, default or dynamic routing depending on what we want to achieve. Configuring the router using static and dynamic routing (EIGRP)

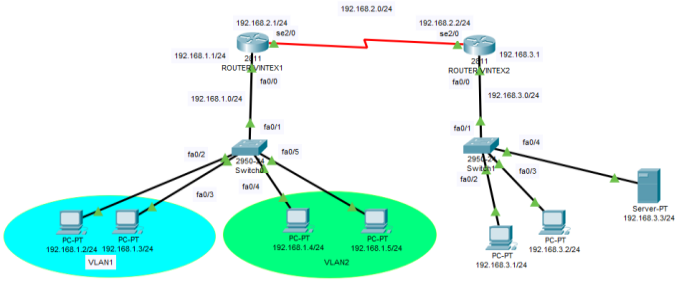


**Fig 14: Network Topology Design**

**Router Configuration on CLI Router 1**

**User Exec Mode:**

Router>enable

**Privilege Mode:**

Router#configure terminal

**Global configuration Mode:**

Router(config)#hostname Vintex1

**Configuration of password**

Vintex1(config)#enable secret VintexR

**Configuration of line VTY for telnetting**

Vintex1(config)#line VTY 0 6
Vintex1(config-line)#password vintexR
Vintex1(config-line)#login
Vintex1(config-line)#exit

**Configuration of line console (port of the router)**

Vintex1(config)#line console 0
Vintex1(config-line)#password vintexR
Vintex1(config-line)#login
Vintex1(config-line)#exit

**Configuration of Banner**

Vintex1(config)#Banner login@
Do not attempt to configure if you are not authorized @
Vintex1(config)#Do copy running config startup-config

**On CLI Router 2**

**User Exec Mode:**

Router>enable

**Privilege Mode:**

Router#configure terminal

**Global configuration Mode:**

Router(config)#hostname Vintex2

**Configuration of password**

Vintex2(config)#enable secret VintexL

**Configuration of line VTY for telnetting**

Vintex2(config)#line VTY 0 6
Vintex2(config-line)#password vintexL
Vintex2(config-line)#login
Vintex2(config-line)#exit

**Configuration *of line console (port of the router)***

Vintex2(config)#line console 0
Vintex2(config-line)#password vintexL
Vintex2(config-line)#login
Vintex2(config-line)#exit

***Configuration of Banner***

Vintex2(config)#Banner login@
Do not attempt to configure if you are not authorized @
Vintex2(config)#Do copy running config startup-config

***Configuration of router interface***

**Router 1(Vintex1)**

Vintex1(config)#interface fa0/0
Vintex1(config-if)#ip address 192.168.1.1 255.255.255.0
Vintex1(config-if)#no shut down
Vintex1(config-if)#exit
Vintex1(config-if)# Do copy running config startup-config

Vintex1(config)#interface serial 2/0
Vintex1(config-if)#ip address 192.168.2.1 255.255.255.0

**Configuration *of clock***

Vintex1(config-if)#clock rate 64000
Vintex1(config-if)#no shut down
Vintex1(config-if)#exit
Vintex1(config-if)# Do copy running config startup-config

**Router 2(Vintex2)**

Vintex2(config)#interface fa0/0
Vintex2(config-if)#ip address 192.168.3.1 255.255.255.0
Vintex2(config-if)#no shut down
Vintex2(config-if)#exit
Vintex2(config-if)# Do copy running config startup-config

Vintex2(config)#interface serial 2/0
Vintex2(config-if)#ip address 192.168.2.2 255.255.255.0
Vintex2(config-if)#no shut down
Vintex2(config-if)#exit
Vintex2(config-if)# Do copy running config startup-config

**Configuring the router using Static Routing**

**Router 1(Vintex1)**

Vintex1>enable
Vintex1(config)#enable secret VintexR
Vintex1(config)#configure terminal
Vintex1(config)#ip route 192.168.2.0 255.255.255.0
Vintex1(config)#ip route 192.168.1.0 255.255.255.0
Vintex1(config)#Do copy running config startup-config
Vintex1(config)#exit

**Router 2(Vintex2)**

Vintex2>enable
Vintex2(config)#enable secret VintexL
Vintex2(config)# configure terminal
Vintex2(config)#ip route 192.168.2.0 255.255.255.0
Vintex2(config)#ip route 192.168.3.0 255.255.255.0
Vintex2(config)# Do copy running config startup-config
Vintex2(config)#exit

**To Verify StaticRouting:**

Vintex2#show IP route

**Configuring the router using Hybrid Routing (EIGRP)**

**Router 1(Vintex1)**

Vintex1>enable
Vintex1(config)#enable secret VintexR
Vintex1(config)#configure terminal
Vintex1(config)#router EIGRP 100
Vintex1(config-router)#ip route 192.168.1.0
Vintex1(config-router)#ip route 192.168.2.0
Vintex1(config-router)#no auto-summary
Vintex1(config-router)#Do copy running config startup-config
Vintex1(config-router)#exit

**Router 2(Vintex2)**

Vintex2>enable
Vintex2(config)#enable secret VintexR
Vintex2(config)#configure terminal
Vintex2(config)#router EIGRP 100
Vintex2(config-router)#ip route 192.168.2.0
Vintex2(config-router)#ip route 192.168.3.0
Vintex2(config-router)#no auto-summary
Vintex2(config-router)#Do copy running config startup-config
Vintex2(config-router)#exit

**To Verify EIGRIP Routing:**

Vintex1#show ipeigrpneighbors (Displays the neighbor table)
Vintex1#show ipeigrp interfaces 100(Shows information for interfaces running process 100)
Vintex1#show ipeigrp topology (Displays the topology table)

**Configuration of the VLAN (on the network switch) for Router 1(Vintex1)**

**In configuring two different Departments**

S1>enable
S1#configure terminal
S1(config)#hostname Vintex1X Switch
Vintex1X Switch(config)#enable secret Vintex1R
Vintex1X Switch (config)#line console 0
Vintex1X Switch (config-line)#password vintex1R
Vintex1X Switch (config)#line VTY 0 - 8
Vintex1X Switch (config-line)#password vintex1R
Vintex1X Switch (config-line)#login
Vintex1X Switch (config-line)#exit

**Configuring access & trunk ports**

Vintex1X Switch#configure terminal
Vintex1X Switch(config)#interface fa0/1
Vintex1X Switch(config-if)#switch port mode trunk

Vintex1X Switch(config-if)# interface fa0/2
Vintex1X Switch(config-if)#switch port access VLAN1
Vintex1X Switch(config-if)# interface fa0/3
Vintex1X Switch(config-if)#switch port access VLAN1
Vintex1X Switch(config-if)# interface fa0/4
Vintex1X Switch(config-if)#switch port access VLAN2
Vintex1X Switch(config-if)# interface fa0/5
Vintex1X Switch(config-if)#switch port access VLAN2

**Configuring the router for the VLAN**

Vintex1(config)#configure terminal
Vintex1(config)#interface fa0/0
Vintex1(config-if)#no ip address
Vintex1(config-if)#no shutdown
Vintex1(config-if)#interface fa0/0.1
Vintex1(config-subif)#encapsulation dot1q1
Vintex1(config-subif)#ip address 192.168.1.2 255.255.255.0
Vintex1(config-if)#interface fa0/0.2
Vintex1(config-subif)#encapsulation dot1q2
Vintex1(config-subif)#ip address 192.168.1.4 255.255.255.0
Vintex1(config-subif)#no shutdown

Vintex1#configure terminal
Vintex1(config)#interface VLAN1
Vintex1(config-if)#ip address 192.168.1.2 255.255.255.0
Vintex1(config-if)#no shut down

Vintex2#configure terminal
Vintex2(config)#interface VLAN1
Vintex2(config-if)#ip address 192.168.1.4 255.255.255.0
Vintex2(config-if)#no shut down

**Naming the VLAN for two different departments**

Vintex1X Switch>enable
Vintex1X Switch(config)#VLAN1
Vintex1X Switch(config-VLAN)#name Admin
Vintex1X Switch(config-VLAN)#exit
Vintex1X Switch(config)#VLAN2
Vintex1X Switch(config-VLAN)#name Finance
Vintex1X Switch(config-VLAN)#exit

To check the configurations:

**At the priviledge mode**

Vintex1X Switch#show vlan(To display information for all VLANs on the switch)
Vintex1X Switch#show vlan brief (To display the VLAN name, status, and associated ports only)
Vintex1X Switch#show vlan summary(To display information about the number of VLANs configured on the switch)

## 3. MAINTENANCE AND TROUBLESHOOTING OF THE NETWORK

Based on the extent on networking in the organization, there arose a need for regular maintaining/ troubleshooting the network to detect and correct the network problems. The various techniques we used in troubleshooting are:

- **PHYSICAL CONNECTION:** We ascertain if there is a physical connection between the computer and the network. It is often displayed as "network cable unplugged". This might require re-crimping the terminating ends of the cable and properly plugging the cable to both the computer and the switch to make sure that there is both traffic and data signal. We also check if the cable is damaged. Also, we can check if the device been connected is powered ON and working correctly by going to the Device Manager.

- **NETWORK IDENTIFICATION:** All computers on the network must have a unique host (computer) name and work group/domain name for easy identification of the computers on the network. All computers in the same school/unit have the same workgroup name. This was manually assigned to monitor the computer system.
- **IP ADDRESS:** We ensured that the IP address were correctly assigned based on its configuration. Also, that the DNS (Domain Name Server) and the port (controls the different ways in which signals are transferred to and from the computer) addresses were assigned correctly. Also, the router is been checked using different IP protocol commands in course of troubleshooting.

**Table 3: Categories of Computer Problems and their Symptoms**

| CATEGORY | SYMPTOMS |
|---|---|
| **ELECTRICAL POWER** | • Dead system (system not bringing up any indication light)<br>• Intermittent errors on power on self-test (POST), intermittent lock ups<br>• Device not working or not found |
| **CONNECTIVITY** | • Device not working, device not found, intermittent errors on a device<br>• Device failure or failure to boot<br>• Check if improperly connected or real failure or warning |
| **BOOT** | • Dead computer<br>• If not, may not be supported with proper drives<br>• Consistent errors on POST<br>• Beep error<br>• CMOS text errors hard disk drive, and video errors |
| **MASS STORAGE** | • Error message<br>• Missing operating system<br>• File not found<br>• No boot device<br>• Abort, retry, fail |
| **OPERATING SYSTEM** | • Error message<br>• Missing operating system<br>• Bad or missing command interpreter<br>• Insert Disk with COMMAND.COM<br>• Stack overflow<br>• Insufficient file handles |
| **VIRUSES** | • Computer runs slow, failure to boot or intermittent locks up, storage problem<br>• Operating system, mysterious symptoms (mostly system on the Net) |
| **NETWORK** | • User forgets password<br>• Expired password<br>• Cable or NIC network interface card (NIC) problems. |

## 4. CONCLUSION

The planning, design and implementation of this project was achieved by adequately carrying out site inspection and evaluation. Also, the network deployment was implemented in four different steps; Router configuration, IP addressing and routing and VLAN.
More so, in the IP routing, it was observed that the EIGRP was better when compared to other methods of dynamic routing because it automatically reacts to network changes and analyses the incoming routing updates.

However, the testing or pre-commissioning analysis was achieved by conducting physical connection examination using cable tester and various IP commands for network connection checks on the installed project. The test results showed that a proper electrical connectivity exists between the computer systems and network equipment for the LAN network. Also, a network identification test was conducted on the project. The results show that the systems under the deployed network have unique host names and workgroup name. Based on these test results the deployed network sufficiently satisfies ISO standard for commissioning, hence, the systems were commissioned and approved for further use.

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