



The Design and Deployment of Computer Networks

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Abstract 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, the nVLAN. 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. 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.

Keywords Local Area Network, Deployment, Network, Topology, Router

Introduction

A network is defined as two or more computer linked together for the communication and sharing information and other resources [1]. 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, three basic requirements must be met. 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. For example, a computer can share a printer or specific directories or files.

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 and Application of Design principle. The various network materials/tools used in



the course of the project include; Fiber Optic Cable/ Unshielded Twisted Pair Cable, Rj45 Connector, Switches, Routers/Wireless Access Point, Modem, Computer Systems/Laptop/Printers and Network Servers

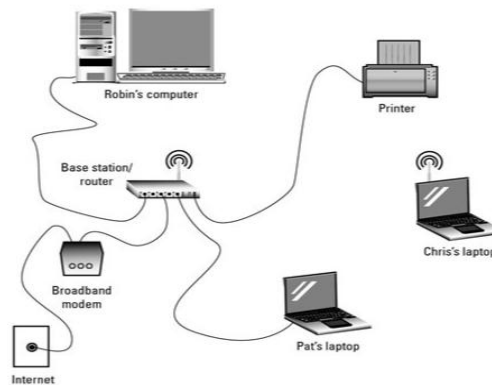


Figure 1: Linking Up of the Computers to the Network Switch for Network Connection

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 this 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:

Physical Topology

The physical topology is the physical shape or layout of the wires which can be seen or visible in a network. It also shows and explains how devices are interconnected with or without wires [1]. They are divided into two:

- Point-to-point connections
- Multipoint connections

Logical Topology

A logical topology is defined as how devices communicate with each other across the physical topology[1]. The logical and physical topologies are independent of each other. The physical topology can also be referred to as the physical layout of the wires while the logical topology is the movement of data through the networks. There are five types of logical topology that are used in a network; namely Star topology, Hierarchical topology, Bus topology, Mesh topology and Ring topology.

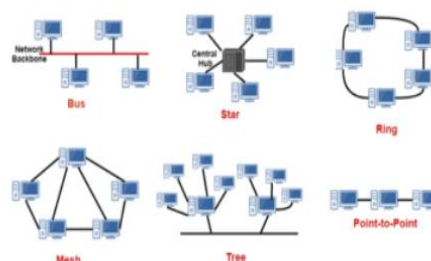


Figure 2: Computer Network Topology



Star Topology

This was used to achieve this work. Star topology is a popular network topology which is used in so many home networks and business in recent times. It has a central connection point called a hub node. This hub node can be an actual hub device, a network switch or a network router. Network devices generally connect to the hub with Unshielded Twisted Pair (UTP) Ethernet cables which is also called an RJ45 cables. Its unique benefit is that failure in any start network cable will only take down one computer's network access but not the entire LAN though if the hub node fails, the entire network will be down.

Types of Computer Network

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

Local Area Network

Local area network or LAN network was implemented in the project. It is made up of a computer network at a single site, probably an individual office building. It can share resources, like data storage & printers. LANs are set up with relatively low cost hardware, like network adapters, hubs, switches and Ethernet cables. Some LAN can even use two computers, while larger LANs can make use of thousands of computers. In most cases, a LAN relies on wired connections for increased speed and security though wireless connections can also be part of it.

Wide Area Network

Wide area network makes use of a very large area, like an entire country or world. It can also contain multiple smaller networks like LANs or MANs. The Internet is the best-known example of a public WAN.

Network Protocols

A network protocol expresses the rules and conventions used for communication between network devices [2]. Network protocols determine the process whereby data is packaged into received and sent messages. Some protocols also encourage message acknowledgment and data compression designed for reliable and/or high-performance network communication [3].

Network Routing Protocols

Routing protocols are important purpose protocols which are specifically designed to be used by network routers via the internet. It is good at the identification of other routers, the management of the pathways (called *routes*) between destinations and sources of network messages, and making of dynamic routing decisions. Common routing protocols include RIP, RIPV2, OSPF, EIGRP and BGP. We used Static and EIGRP routing protocols because it is generally accepted.

Network Computer System Installation

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. There is a connector called an RJ45 connector at each end of a cable.

Network equipments are categorized into two:

- **Data Terminal Equipment (DTE):** Used in terminating the network. Here, we have computers and router. Note when there is no clock on a router is a DCE.
- **Data Communication Equipment (DCE):** Used in extending communication (flow of data communication). For example, in LAN (Switches, hubs), WAN (CSU/DSU, frame relay switch).

Types of Ethernet Cables

Ethernet cables are in two forms with respect to wiring:

- Straight-through cable
- Crossover cable
- Roll over cable



Straight-through cable

This cable type wiring is identical on both ends (pin 1 at one end of the cable is connected to pin 1 on the other end of the cable, pin 2 is connected to pin 2 etc.).

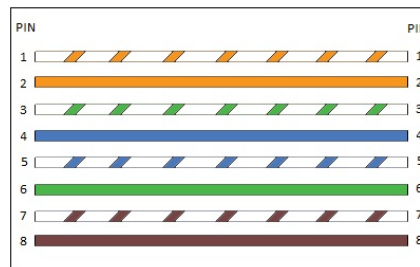


Figure 3: Straight-Through Wiring

They are used in connecting of two dissimilar devices like DTE to DCE. This cable can be used to connect these devices:

- computer to hub
- computer to switch
- router to hub
- router to switch

Computers and routers use wires 1 and wire 2 to transmit data. They also use wires 3 and wire 6 to receive data which is the reverse of the early. But, Hubs and switches use wires 1 and wire 2 to receive data while they make use of wires 3 and wire 6 to send data. That is the reason why a crossover cable is needed to connect two computers together.

Crossover cable

Wire pairs are swapped, thereby connecting different pins together – pin 1 at one of the cables end is connected to pin 3 on the other cables end. Then, pin 2 at one end is connected to pin 6 on the opposite end

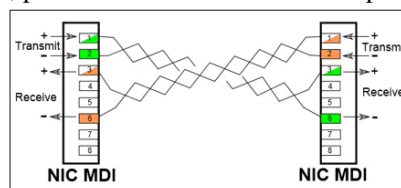


Figure 4: Crossover Wiring

They are used in connecting of two similar devices like two DTE or two DCE. This cable type is used for the connection of the following devices:

- computer to computer
- switch to switch
- switch to hub

Rollover Cable

This is used for configuration that is between the computer and the router/switch. It is not used in networking.

Categories for Ethernet Cables

During the Ethernet and other telecommunications / networking applications, cables of different variety are available. These cables are expressed by their different categories, e.g. Cat 5 cables and Cat 6 cables are often used. It is observed by the telecommunications Industries Association which are summarised as follows:

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	

Figure 5: 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.



Figure 6: 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.



Figure 7: 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.



Figure 8: Cable Tester

IP Addressing

IP address 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.

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 observe the destination IP address of a packet and also confirm the next-hop address, then make sure the pack is forward with the use routing.

VLAN

VLANs (Virtual LANs) are grouping of devices logically within same broadcast domain. They are often developed on switches and this is done by placing some interfaces into one broadcast domain and some others into another. It can be spread among several or multiple switches, with each VLAN treated as its own subnet or broadcast domain thereby making the frames broadcasted onto the network to switch only between the ports within the same VLAN [7].

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)



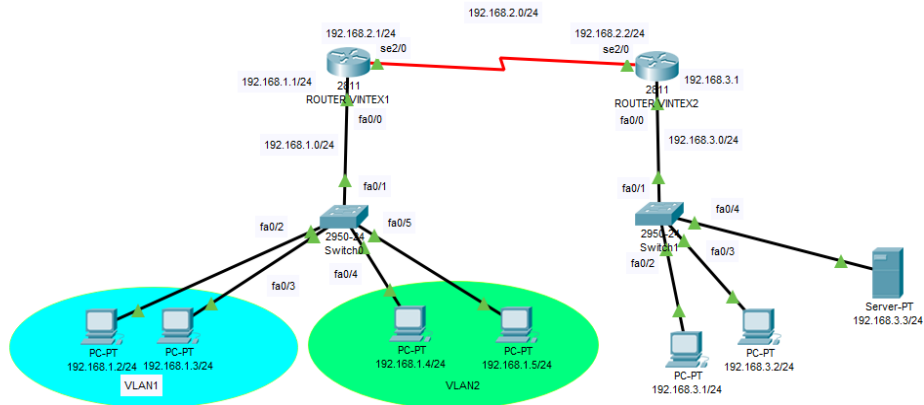


Figure 9: Network Topology Design

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 ip eigrp neighbors (Displays the neighbor table)

Vintex1#show ip eigrp interfaces 100 (Shows information for interfaces running process 100)

Vintex1#show ip eigrp 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)
```

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 1: Categories of Computer Problems and their Symptoms

Category	Symptoms
Electrical Power	<ul style="list-style-type: none"> • Dead system (system not bringing up any indication light) • Intermittent errors on power on self-test (POST), intermittent lock ups • Device not working or not found
Connectivity	<ul style="list-style-type: none"> • Device not working, device not found, intermittent errors on a device • Device failure or failure to boot • Check if improperly connected or real failure or warning
Boot	<ul style="list-style-type: none"> • Dead computer • If not, may not be supported with proper drives • Consistent errors on POST



	<ul style="list-style-type: none"> • Beep error • CMOS text errors hard disk drive, and video errors
Mass Storage	<ul style="list-style-type: none"> • Error message • Missing operating system • File not found • No boot device
Operating System	<ul style="list-style-type: none"> • Abort, retry, fail • Error message • Missing operating system • Bad or missing command interpreter • Insert Disk with COMMAND.COM • Stack overflow • Insufficient file handles
Viruses	<ul style="list-style-type: none"> • Computer runs slow, failure to boot or intermittent locks up, storage problem • Operating system, mysterious symptoms (mostly system on the Net)
Network	<ul style="list-style-type: none"> • User forgets password • Expired password • Cable or NIC network interface card (NIC) problems.

Safety Precautions in Networking

The following Safety and Guidelines are for safety while working:

- Avoid working alone. In any case of emergency, the presence of another person(s) may save the day.
- Wear clothes and rubber bottom shoes or sneakers.
- Don't wear any jewellery or other materials that could accidentally contact circuitry and conduct current, or get caught in moving parts.
- Avoid executing repair work when in a tired state. There tend to be carelessness in such a state. The primary diagnostic tool may work in full capacity.
- Avoid making assumptions on anything without checking it out for yourself. Don't take shortcuts.

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, the nVLAN. 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.

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