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Network Protocol – Computer Comms:

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Introduction:- Network Protocol, and why TCP/IP has become the standard Protocol .

- With development of TCP/IP (Transmission Control Protocol / Internet Protocol), Networking has improved our lives tremendously. A single printer purchased for the office, could be connected to the LAN (Local Area Network) and once the LAN is up , one could sit behind his computer anywhere in the office and print onto that printer.

Network Protocol, and why TCP/IP has become the standard protocol - cont'd

- Again with the development of the TCP/IP, we have today the Internet, which has changed our lives so much. Associated with the Internet is the Electronic Mail (E-mail), which one can easily send e-mail message from his or her machine to a friend or a relation located anywhere in the world. Communication has impacted on our social and economic lives.

Network Protocol, and why TCP/IP has become the standard protocol,- cont'd

- Also with the development of TCP/IP, one can be in Ghana and FTP a file from a computer located say Brussels or any part of the world onto his or her computer. Similarly, one could telnet from his or her machine in Ghana to another machine located in USA and start working on that machine. All that is required is to know the IP address of that machine you want to "talk" to.

Network Protocol and why TCP/IP has become the standard protocol cont'd

- At this point mention should be made of Vinton G. Cerf, who co-developed the computer Networking protocol TCP/IP and the architecture of the Internet and holds numerous awards in connection with his works on the Internet. Mention should also be made of Robert Kahn who has done so much in this area.

What is this Network Protocols ?

- These protocols are nothing but a set of strict rules for the exchange of information. Example is, whenever you are involved in telephone conversation, there is a protocol at play.
- Protocols are also the software that enables the exchange of information among computers. Examples are TCP/IP, NWLink IPX/SPX Compatible Transport and NetBEUI

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Common Protocols include the following:

TCP/IP – This suite of networking protocols provides communication across interconnected networks.TCP/IP is the required for Internet communications.

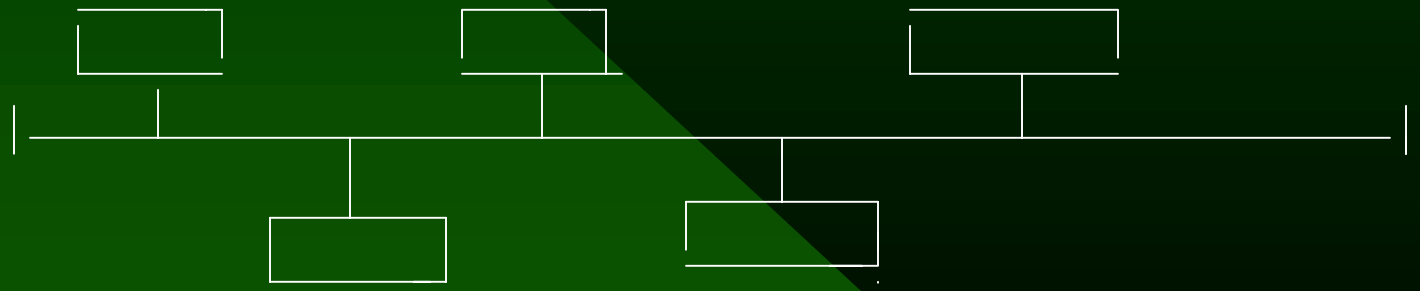
NWLink IPX/SPX compatible Transport – For many sites, this is the standard network protocols. It supports routing, and it supports Netware client – server applications, where Netware, socket-based applications communicate with IPX/SPX sockets based applications. Choose this option if your computer is connected to or communicate with a Netware network.

Common protocols cont'd

- **NetBEUI**: This protocol is usually used in small, department size, local area network of 1 to 200 clients. It can use Token Ring source routing as its only method of routing. Choose this option if your computer is connected to or communicate with a Netware network.

Network Overview

- **LAN** – A local network is normally used to connect computers, which are geographically close. For instance, computers in an office are connected together in a LAN.



Network Overview cont'd:

- TCP/IP is the protocol normally used on LAN
- Other protocol used on LAN are Novell Netware and IPX.
- **WANs -** WAN (Wide Area Network) is normally used to connect computers which are geographically distant. Most country offices are connected together by WAN. Normally WAN technologies works slower that LAN and MAN (Metropolitan Area Networks) but over greater distances.

Network Overview cont'd:

- Typically WAN will run at the speeds of 9.6 kbps to 45 Mbps. Historically WAN used the X.25 protocol, which did a lot of error checking.
- New network protocols like frame relay are emerging now which does away with a lot of error checking.

Network Overview cont'd:

- **SITA:** Within DHL (International Courier company) where I used to work, we used x.25 as the protocol on WANs. DHL does not actually have a WAN itself but used the one provided by SITA (Societe International de Telecommunications Aeronautics Society Co-operative). SITA is used by the airlines and their partners. DHL sends its data to SITA via X.25; SITA then converts the X.25 protocol into SITA protocols for internal transmission.

Network Overview cont'd:

internet : The internet (lowercase I) is a collection of networks joined by a common protocol (normally TCP/IP) to create a single logical network.

Internet: The Internet (uppercase I) is a worldwide collection of internet, which grew out of the original ARPANET. The Internet uses TCP/IP to link many internets into one logical worldwide network. The Internet can be seen a special network of networks.

Network Overview cont'd:

- **DHLNET** : The DHL communications environment is complex and diverse. It consists of a number of country networks which link into the global network. The DHLNET is the short for DHL Network and encompassed both LAN and WAN technology.
- In summary, Network has grown tremendously because they are useful as they allow information to be shared. Information is useless unless it is shared and network allows you to do this.

X.25

- **X.25 Protocol**: X.25 is an international recommendation for public data networking. The recommendation is defined by ITU. X.25 is described as a network, which allows “a universally available, low cost, wide area, open systems, packet switched networking service “.

TCP/IP

- **TCP/IP**: (Transmission Control Protocol / Internet Protocol) is an example of a packet switched network.
- The result of the research into network by the US Defence Department through its Defense Advanced Research Project Agency (DARPA) in the mid 1970s is the TCP/IP Protocol suite.

TCP/IP cont'd ….

- - The specification for TCP/IP were made publicly available by means of Internet Request for Comments.
- ARPANET : In 1980, TCP/IP was sufficiently developed and standardized that it was deployed on a network known as the ARPANET. As US funding started to disappear for the backbone, the ARPANET became known as the **Internet**.

TCP/IP cont'd …..

- IP – Is responsible for moving packet of data from node to node. It forwards each packet based on a four-byte destination address (the IP number). The Internet authorities assign ranges of numbers to different organizations. The organizations assign groups of their numbers to departments. IP operates on gateway machines that move data from department to organization to region and then around the world.

TCP/IP cont'd .....

- **TCP** – Is responsible for verifying the correct delivery of data from client to server. Data can be lost in the intermediate network. TCP add support to detect errors or lost data and to trigger retransmission until the data is correctly and completely received.
- **Sockets** – Is a name given to the package of subroutines that provide access to TCP/IP on most systems.

IAB

- The Internet Activities Board (IAB), which was established in 1983, manages the Internet. This body provides overall direction and co-ordination for further development of TCP/IP and administrative control for the Internet.
- Since 1990, the growth of the Internet has been phenomenal.

Features of TCP/IP

- The popularity of TCP/IP did not grow just because the protocols were “free”. TCP/IP offers several important features:
- **Open “standards” as defined in the RFCs.**
- **-** This means that TCP/IP is independent from any specific hardware or software vendor.

Features of TCP/IP cont'd ….

- **Physical Independence**:
- - TCP/IP is also independent from the underlying physical network. This means that TCP/IP can be used (tunnelled) over virtually any type of physical network, such as X.25, Ethernet, or even UUCP.

Features of TCP/IP cont'd ….

- **Common Addressing:**
- TCP gives each host on a network a unique network address, called IP address which has a standard format. This allows any network device to "talk" to any network device. For instance a host computer can "talk" to a printer via TCP/IP.

Features of TCP/IP cont'd

- **Network Management:**
- **TCP/IP includes a protocol called simple Network Management protocol (SNMP), which allows both local and remote Network Management. This protocol is used by the DHL NMS (Network Management System) product.**

Features of TCP/IP cont'd

- **Application Standards:**
- TCP/IP has standardized protocols for user services. Example of such services are ftp (file transfer), smtp (electronic mail) and telnet login (remote login).

TCP/IP – Protocol Architecture

- Although there is no “standard” for the actual architecture of TCP/IP, normally it can be logically defined in the following stack.
- **Network Access Layer** :
- - The Network Access Layer is the lowest of the TCP/IP model and defines how the network is used to transmit the data. Users have no need to use this layer, as it is normally hardware, which access it.
- **Internet Layer** :
- The Internet layer is the heart of TCP/IP. At this level, such thing as addressing standards, routing and fragmenting of network data in manageable chunks is done. All data, both incoming and outgoing flows through this layer

TCP/IP – Protocol Architecture cont'd ….

- **Transport Layer**:
- - The Transport layer is the one, which defines error correction (via TCP) and delivers data between the application layer and the Internet layer.
- **Application Layer**:
- The Application Layer is the one, which provides user services such as telnet, FTP and nfs.

TCP/IP – IP Address

- An IP address is defined as a 32-bit address, which is broken into 4 octets separated by full stops. This address is sometimes referred to as the decimal dotted address. As an octet is 8 bits, the minimum value an octet can have is 0 and the maximum value is 255.
- **Class A :** 0.0.0.0 - 127.255.255.255
- Class B : 128.0.0.0 – 191.255.255.255
- Class C : 192.0.0.0 - 223.255.255.255

TCP/IP – IP Address cont'd …..

- **Class D :** 224.0.0.0 - 247.255.255.255
- **Class E :** 248.0.0.0 - 255.255.255.255
- The IP address contains a network part and a host part. Depending on each of these address bits, an IP address falls into different classes ; thus A,B,C,D and E as has been indicated above. Of these 5 classes, 3 are used ,with the class D and E being normally reserved.

Address Class	# Network Bits	# Hosts Bits	Decimal Address Range
Class A	8 bits	24 bits	1-126
Class B	16 bits	16 bits	128-191
Class C	24 bits	8 bits	192-223

TCP/IP – IP Address cont'd

- The following are examples of Class C type IP Address:
- 1. 198.141.132.1
- 2. 198.141.92,181

TCP/IP – IP Address cont'd

- **Reserved Address**: As well as reserving all IP addresses with a first byte larger than 223, there are some special addresses, which cannot be used.
- Broadcast Address: An IP address with all host bits set to 1 such as 198.141.32.255 refers to broadcast address. A broadcast address is used to send information to every host on a particular address.

TCP/IP – IP Address cont'd

- **Loopback Address**: There are two class A networks , 0 and 127, which are reserved. The 0 network is used for the default route and 127 is used for the loopback address. The loopback address is a special one, which allows programmers and users to check the valid operation of the TCP/IP software without actually going outside of the host machine.

TCP/IP – IP Address cont'd

- Network Address: In addition, there are some host addresses, 0 and 255, which are also reserved. An IP address, which has all host bits, set to 0 such as 198.141.32.0 refers to the entire 198.141.32 network (I.e all address between 198.141.32.1-254) and 137.98.0.0 refers to the 137.98 network. These types of addresses are used in routings (as in the 0 network.)

TCP/IP - Subnetting

- In order to allow decentralization of the address space, the process called Subnetting is used. Subnetting effectively changes the number of bits assigned to the network part of an IP Address. Subnetting is normally done to allow an organization to “cut” up it IP address space into more manageable sections. Using a SUBNET mask creates a subnet.

An Overview of the Classless Inter-Domain Routing (CIDR)

- CIDR is a method of addressing for the Internet which allow for more efficient allocation of IP addresses than the old Class A,B, and C address scheme, which have been explained above.
- The Internet authorities felt it more wise to introduce this CIDR, because they knew that if we continue to use the old Class, there is likelihood of running out of IP address and the capacity in the global routing tables.

Running Out of IP Addresses

- Using the old Class A,B, and C addressing scheme explained above, the Internet could support the following:
- - 126 Class A networks that include up to 16,777,214 host.
- - Plus 65,000 Class B networks that could include up to 65,534 host each.
- Plus over 2 million Class C networks that could include up to 254 hosts each.

Running Out of IP Addresses cont'd

- Because the Internet addresses were generally only assigned in these three sizes, there was a lot of wasted address. For example , if you needed 100 addresses you would be assigned the smallest address (Class C), but still meant 154 unused addresses. The overall result was that while the Internet was running out of unassigned addresses, only 3 % of the assigned addresses were actually being used. CIDR was developed to be a much more efficient method of assigning addresses.

Global Routing Tables At Capacity

- Another issue to look at is the size of the Internet global routing tables. As the number of networks on the Internet increased, so did the number of routes.
- Using the old router technology, the maximum theoretical routing table size was approximately 60,000 routing entries. If nothing was done the global routing tables would had reached capacity by the middle of 1994 and all Internet growth would have halted.

How were the Problems discussed solved ?

- Two solutions were developed and adopted by the global community:
- - Restructuring IP address assignments to increase efficiency.
- - Hierarchical routing aggregation to minimize route table entries.

Restructuring IP Address Assignments

- Classless Inter-Domain Routing (CIDR) is a replacement for the old process of assigning Class A,B and C addresses with a generalized network “prefix”. Instead of being limited to network identifiers (or “prefix”) of 8,16 or 24 bits, CIDR currently uses prefixes anywhere from 13 to 27 bits. Thus, blocks of addresses can be assigned to networks as small as 32 hosts or to those with over 500,000 hosts.This allows for address assignments that much more closely fit an organization’s specific needs.

Restructuring IP Address Assignments cont'd.

- A CIDR address includes the standard 32-bit IP address and also information on how many bits are used for the network prefix. For example, in the CIDR address 206.13.01.48/25, the "25" indicates the first 25 bits are used to identify the unique network leaving the remaining bits to identify the specific host.

Restructuring IP Address Assignments cont'd

CIDR Block Prefix	# Equivalent Class C	# of Host Address
/27	1/8th of a Class C	32 hosts
/26	1/4th of a Class C	64 hosts
/25	½ of a Class C	128 hosts
/24	1 of Class C	256 hosts

Restructuring IP Address Assignments cont'd

CIDR Block Prefix	# Equivalent Class C	# of Host Address
/23	2 Class C	512 hosts
/22	4 Class C	1,024 hosts
/21	8 Class C	2,048 hosts
/20	16 Class C	4,096 hosts

Hierarchical Routing Aggregation to minimize Routing Tables Entries

- Apart from the IP Address assignments restructuring, the CIDR also enables “route aggregation”. What this means is a single high-level route entry can represent many lower-level routes in the global routing tables.
- Currently, big blocks of addresses are assigned to the large Internet Service Providers (ISPs) who then reallocate portions of their address blocks to their customers. Currently, the global routing tables have approximately 35,000 entries.

Impacts on User

- Currently, the Internet is a mixture of both old Class A,B, and C addresses and the “CIDR-ized ” addresses. Almost all new routers support CIDR and the Internet authorities strongly encourage all users to implement the CIDR addressing scheme.
- The conversion to the CIDR addressing scheme and route aggregation has two major user impacts:

Impacts on User cont'd

- **- Justifying IP Address Assignments**
- **- Where to Get Address Assignment**

Justifying IP Address Assignments

After the introduction of the CIDR, the Internet is still growing at a fast pace that address assignments will continue to be treated as a scarce resource. The current Internet guideline is to assign addresses based on the organization's projected three-month requirements with additional addresses assigned as needed.

Where to Get Address Assignments

- In the past, you would get a Class A,B, or C addresses assignments directly from the appropriate Internet Registry (I.e the InterNIC). Under this scenario, you "owned" the address and could take it with you even if you changed Internet Service Providers(ISPs). With the introduction of CIDR address assignments and route aggregation, with a few exceptions, the recommended source for address assignments is your ISP. Under this scenario, you are only "renting" the address and if you change ISPs it is strongly recommended that you get new address from your new ISP and re-number all your network devices.

Where to Get Address Assignments cont'd

- In conclusion, the implementation of the CIDR has been critical to the continued growth of the Internet, allowing more organizations and users to take advantage of this increasing vital global networking and information resource.

TCP/IP - Protocols

- In order for hosts to communicate with each other they must use protocols. TCP/IP is a suite of protocols , therefore how do hosts know what protocol to use when they wish to communicate with each other ?
- In every TCP/IP packet sent across a network, there is a part, which defines an 8-bit protocol number. This protocol number is used to “translate” the TCP/IP packet into the correct protocol.

TCP/IP – Protocols cont'd

- The protocol numbers are easy for a computer to remember but what about humans. On UNIX systems, this file is normally found as /etc/protocol file, example of which is below:
- @ Protocols
- Ip 0 IP @ internet protocol, pseudo protocol number
- Icmp 1 ICMP @ internet control message protocol

TCP/IP – Protocols cont'd

- @ Protocols
- tcp 6 TCP @ transmission control protocol
- udp 17 UDP @ user datagram protocol
- raw 255 RAW @ RAW IP interface
- The format of the file is one line per entry with each line consisting of the official protocol name , followed by the protocol number.

TCP/IP – Protocols cont'd

- So exactly how does this help us ? When a TCP/IP packet arrives at a machine, that machine must decide which protocols are required. This is done by looking at the protocol number in the packet and then checking this against the value in the /etc/protocols. Therefore an incoming packet with a protocol number of 17 will be handed to UDP to deal with, whilst a packet with 0 will be passed to IP.

Protocols and Standards:

- Protocols specify the rules for communication. They are the building blocks that turn cables and attached computers into smoothly functioning communication systems. Without protocols network communication would be haphazard and inefficient at best. A protocol specification formally documents a protocol. Protocol specifications describe how to build networks. They detail the order in which computer devices are allowed to communicate on a shared transmission medium. A protocol implementation is one vendor's implementation of a particular protocol.

Protocols and Standards cont'd:

- Network vendors produce their own implementations of protocol specification. For example the term "TCP/IP" refers to two specific communication protocols (TCP and IP) offered by literally hundred of vendors. Each implementation is slightly different from all the others.
- Protocols that have acquired widespread support over time are called standards. Protocol may become standards as a result of superior features or simply because they are supported by large, influential vendors.

Protocols and Standards cont'd:

- In the mid 1980's the institute of Electrical and Electronic Engineers (IEEE) developed a series of specification that have become the most popular LAN protocols currently available. These protocols are referred to as the IEEE 802 series. Included in this suite of protocol are IEEE 802.2 , IEEE 802.3 and IEEE 802.5

DNS

- A study of the Internet will not be complete without the mention of DNS. DNS is the acronym for Domain Name Service. There are defined top-level domains, which every domain on the Internet must conform to. These top-level domains can be broken down into two different types – organizational and geographical. For instance, the top level organizational domains, can be .COM (for commercial), .EDU(for Educational), GOV., (for government) and NET.

DNS cont'd

- The top-level geographical hosts in GH normally end in .gh, whilst machines in US end in .us and in the UK end in .uk. In fact, industries in Ghana follow these international standards. In fact it is realised that the e-mails address and the web site address(I.e URL – Universal Resource Locator) are based on DNS. Examples of e-mail and sites addresses of certain industries in Ghana are as follows:

DNS cont'd

- 1. reisco@ncs.com.gh (I.e e-mail created from NCS (Network Computer System Ltd) server.
- 2. www.africanonline.com.gh (I.e Web site address for African Online Ghana Ltd.)
- 3. doss@idngh.com (i.e e-mail address created from IDN's server)

DNS cont'd

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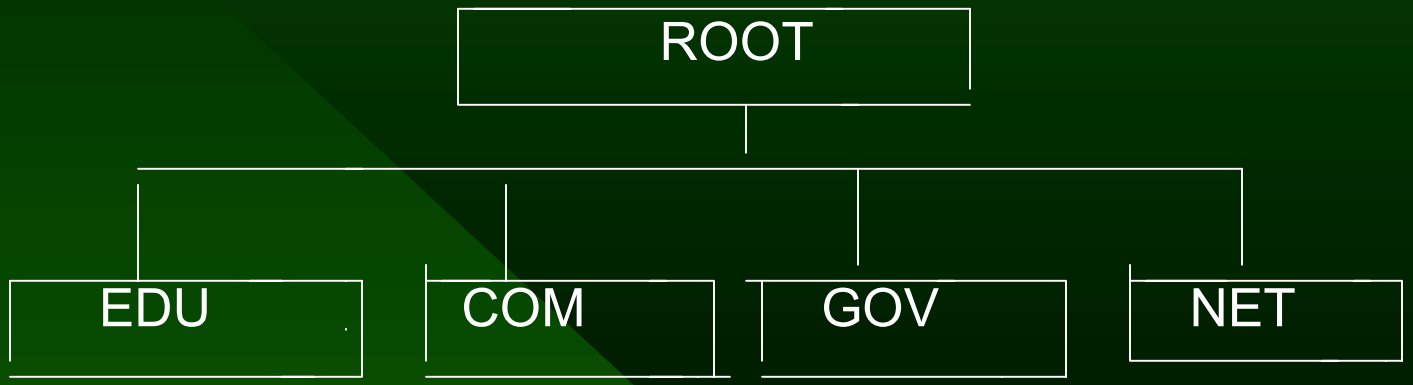
-
-
- NB: Most URL's and e-mail addresses of Ghanaian companies and others worldwide come under COM in the above diagram.



Internet in Ghana

- Most ISPs in Ghana adopts the following method of connection:
- a) Dial – up
- b) The use of radio modem
- C) Satellite connectivity
- The early ISPs in Ghana started with Dial-ups, but soon their clients (I.e cafes) started complaining due to poor connectivity with regards to access. Later a few ISPs came into the system , which started with the use of radio modems for their connectivity. Initially services were quite OK, but with the growth of their client size, access to the Internet degenerated since most of these ISPs didn't want to increase their bandwidth.

Internet in Ghana cont'd

- One of the best forms of this connectivity is the satellite, which so far only one Public Internet Access company has adopted. The name of the company is BusyInternet. Because of the good services the company offers it has won words like "BusyInternet is the smart choice for smart people".
- Some of the ISPs in Ghana are as follows:
- - Network Computer Systems (NCS) Ltd.

Internet in Ghana cont'd

- - IDN
- - African On-line Ghana Ltd.
- - Internet Ghana (I.e Broadband Internet Service)
- - World Wide Web (WWW) Plus
- The problem which some of the clients (I.e Internet cafes) to these ISPs face are so peculiar that a thorough study is required to address the issues.

Security

- Security on any network like Internet is very important; this can be comparable to a door to a house. After you have put the entire best infrastructure in place, security is critical to the successful operations of your system.
- Any host connected to any network, particularly the Internet, are open to security breaches. These breaches can range from unauthorized access, crashing your host, to endangering the entire network. Other issue to look at will be routers and firewalls. Thus a router can be set up to stop unwanted IP traffic, whereas firewalls are systems put in place to stop any traffic from the “dirty” side to pass

Security cont'd

- directly through to the "clean" side. A firewalls are multi-homed host, which does not forward TCP/IP packets. These packets are passed through the Internet layer and the transport layer to the application layer.
- Some strategies, which can be put in place to guard against the security of your system, are as follows:
- a) Regarding access to your computer system, you must ensure you have good passwords to your login ids.

Security cont'd

- b) There is always the need to have good back-ups system for your computer room, I.e both on-site and off-site. Who knows, the computer room can catch fire one day.
- C) Above all, these days where viruses are very common, there is always the need to have current anti-virus software installed on your servers and workstations, which have hard disks. Examples of some of the anti-virus software are McAfee anti-virus software and Norton anti-virus software.

Conclusion

- The composition of the Internet, thus e-mail and World Wide Web are what Larry Downes and Chunka Mui call the “Killer Apps” in their book entitled, “Unleashing the Killer Apps”. These killer apps have profoundly influenced and even altered society far beyond their intended use.
- Through the efforts of Vinton G. Cerf and Lawrence Kahn, whose names have been mentioned above, today we have these Internet being used everywhere in the world, including Ghana.

Conclusion cont'd

- Although we have a lot of technologies being used to give access to the Internet in Ghana an other parts of Africa, some of the infrastructures are not well developed. The major factor being economic.Others see it as lack of technological know how, but in this era that we find ourselves, with the availability of funds, I believe the right infrastructure can always be adopted.