Analysing Transmission Of Information In Local Area Network: Case Study Of Koforidua Technical University Computer Network

Seth Okyere-Dankwa[1], Mensah Sitti[2], Solomon Anab[3]

[1]Dean, School of Graduate Stadies, Koforidua Technical University,
Koforidua, Ghana PH +233208114115
Seth.okyere-dankwa@ktu.edu.gh

[2]Lecturer, Computer Science & Eng. Dept. University of Mines & Technology,
Tarkwa,Ghana PH +233208351347
msitti@umat.edu.gh

[3]Lecturer, Computer Science Department, Koforidua Technical University,
Koforidua, Ghana PH +233243158668
solomon.anab@ktu.edu.gh

Abstract: As a result of the exponential growth and technological advancement in the field of communication and networking, it is expedient to analyse transmission of information with regard to Local Area Network (LAN) availability. LAN normally faces problems with congestion and scalability. This study focuses on protocols governing global communication, comparison between OSI and TCP/IP models, procedures that Data goes through before being transmitted through a media. The Study will finally look at the Koforidua Technical University Network, make critical analysis of the media types and also make necessary recommendation for it optimum utilisation.

Keywords: MTU, NFS, OSI, PDU, TCP, TCP/IP, UDP

1. Introduction

According to [1], Open System Interconnection (OSI) Reference Model offers a model for computer networking. International Standard Organisation (ISO) defined this model and it consists of seven layers. The layers are: Application, Presentation, Session, Transport, Network, Data Link and Physical. Software issues are implemented at Application, Presentation, Session, Transport and Network layers. Data Link and Physical layers implement both hardware and software issues. Each of these seven layers has protocols which aid in the transmission of message from one user to another. During message transmission from one network to another, the message runs through the layers undergoing different metamorphosis. Messages pass between layers within the same machine is called Service Data Unit (SDU) and messages which the sending machine on one layer send to a corresponding layer on the receiving machine is called Protocol Data Unit (PDU).

1.1 Related Works

Sending e-mail for example from the Koforidua Technical University Network will go through the school's network as follows:

1.1.1Application Layer:
The application layer is the layer which is very close to the user. It is different from other layers because it does not offer services to any other OSI layer. It offers user application like spreadsheets, word processors, telnet, browsers with network services such as Internet access, file access and shared printing. The E-mail file from the Koforidua Technical University campus is received in this layer.

1.1.2 Presentation layer:
The E-mail file is then converted to a format which is suitable for the machine. The layer also takes care of compression/decompression and encryption/decryption and is associated with such formats as GIF and JPEG [20].

1.1.3 Session layer:
The session layer defines the arrangement of transmission of the E-mail file over the network, Network File System (NFS) utilises Remote Procedure Call (RPC) to manipulate interpretation of user and machine names. The layer also controls dialogues and conversation. [12].

1.1.4 Transport layer:
The transport layer breaks the E-mail file from the host in the Koforidua Technical University Network down into segments and reassembles the segments received into Data. The transport layer manages the reliability and quality of the transmitted data. The data at this layer is in the form of packets and are sequenced. The main protocol is Transmission Control Protocol (TCP). The TCP set up links between a destination and source port number and also maintains that packet delivery is in order and resent are ensured. The transport layer is a bit slow because a lot of error-correcting activities are undertaken [8].

1.1.5 Network layer:
Network layer uses NetWare IPX as its protocol and is responsible for arranging logical connection between source and destination nodes on the network. Management and selection of route for information flow between source and destination nodes depend on the available data path. Services identified in this layer include switching, routing, addressing, sequencing and flow control procedures [16]. According to [19], headers and footers are added to the packet to make them suitable for transmission. The most import elements in

the header is the destination address and the sources address which is the IP addresses of the sending and receiving machines.

1.1.6 Data Link layer:
At this layer, packets from network layer are broken into frames suitable for transmission over the implemented network technology. Different network technologies, for example Token Star and Ethernet have different frame sizes and composition. The data link layer uses Ethernet protocol which ensures that data travelling along the physical medium get to their destination in an error –free manner. The protocols at this layer have some device of checking errors and retransmission of problem packets. Large pockets which are sent through the data link layer are handled by the Maximum Transmission Unit (MTU). According to [2], the Data link layer controls two sublayers: the logical link control (LLC) and Media Access Control (MAC). LLC take care of generation and interpretation of commands that deliver the flow of data and error recovery. The MAC on the other hand is responsible for providing access to the local area network. It also enables a node on the network to transmit information. According [2] MAC address use in this layer is a collection of 6 bytes of information with hexadecimal numbers eg 08:CA:00:12:34:56.

1.1.7 Physical Layer:
The physical layer uses RS – 232 protocol to create the physical connection between a computer and the network. It manages the flow of information and identifies the mechanical and electrical features of the protocol in terms of connectors size, voltage levels, pin assignments, physical data rates. Data is passed to the physical layer as a series of bits that is in the form of 1s and 0s which are converted into electrical signals for transmission. Depending on the type of connection, the stream may be serial or parallel and transmission may be either duplex (able to send and receive simultaneously) or half – duplex (only able to send or receive at any given time [3].

1.2 Objective
The main objective is to establish the problems associated with the protocols governing the communication on Koforidua Technical University's LAN. This will be achieved through the following specific objectives:
1. To review TCP/IP.
2. To compare and contrast TCP/IP and OSI Reference Models.
3. Identify TCP/IP and OSI Models and their suitability for describing global communication.
4. To critically analyse Koforidua Technical University network and find solution in terms of different media to optimise the network

2. OVERVIEW OF TCP/IP
The construction of TCP/IP model is centred around four-layer scheme as against seven layers on OSI model. Although, there are some omissions of descriptions found in the OSI model. The TCP/IP combines and splits some of the adjacent layers of OSI model. The four layers described by TCP/IP are: Data Link layer, Network layer, Transport layer and the Application layer [15].

2.1 Application layer:
Several protocols constitute the Application layer of the TCP/IP suite. The layer houses end user applications like: Telnet, FTP, SMTP, DNS, RIP, NFS.

2.2 Transport layer:
The layer is responsible for delivery pockets between Application layer and network layer. There are two types of protocols which operate at this layer. They are TCP and User Datagram Protocol (UDP). TCP is a connection – oriented protocol which is responsible for reliable data delivery. UDP on the other hand is a connectionless-oriented protocol, It transmits data onto the network with destination address and assumes that it will get to its destination. The network does it best to deliver the data, the problem occurs when there exists multiple path. An out of sequence packet delivery occurs. According to [1], UDP is good for broadcasting pocket to send data to all hosts on the network.

2.3 Internet layer:
This layer employs the services of Internet Protocol (IP) which is the most important protocol in this layer. It controls all traffic both incoming and outgoing. The primary function of IP is to route packets between nodes. This is achieved by using its addressing scheme. The IP address consists of 4 bytes or octets, which contain both a network and a node address eg. 165.8.1.1. Internet Protocol is a connectionless protocol and does not guarantee delivery of pockets across the network. The IP is a connectionless –oriented protocol so at an extreme case it depends on the protocols from either Transport or Application layers. Other protocols like Internet Control Message Protocol (ICMP) permits hosts and routers to send error or control messages to other routers and host. Address Resolution Protocol (ARP) converts a host's software address to a hardware address, this is used to convert IP Address to MAC Address on the address resolution table. The Reverse Address Resolution Protocol (RARP) does vice versa by converting MAC address to IP address [5].

2.4 Network Access
Layer: The principal function of this layer is formation of network packet and use of MAC address to transmit packets on the network segment. Electrical and mechanical specifications that permit communication to be effected are defined. The layer ensures that by means of Frame Check Sequence (FCS), pockets which have suffered interference are prevented from entering into Network layer. FCS does some calculations on the packet of the sending machine, if the receiving machine does similar calculation on the received packet and is not the same, the packet is rejected.

3. Methodology
The study adopted Mixed method. Under this strategy, more emphasis was placed on Case Study which falls under qualitative research.

3.1 THE SIMILARITIES BETWEEN TCP/IP AND OSI REFERENCE MODELS:
a. TCP/IP and OSI models have similar architecture, that are both segmented into layers.
b. Both OSI and TCP/IP models have Application layers, TCP/IP application layer integrates the session and presentation layers.

c. Transport layer of both TCP/IP and OSI models consist of TCP which is a connection oriented protocol and it ensures reliable delivery of packets.
d. TCP/IP and OSI models assume packet exchange [10].

3.2 THE DIFFERENCES BETWEEN TCP/IP AND OSI REFERENCE MODELS:

a. TCP/IP combines the presentation and session layers into application layer.
b. The Transport layer of TCP/IP consist of Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) .UDP is a connectionless – oriented protocol which does not ensure reliable packet delivery, whilst the Transport layer of the OSI model consist of only TCP which is a connection oriented protocol and ensures reliable delivery of packets.
c. The fewer layers in the TCP/IP make it appear simpler than OSI model.
d. TCP/IP model has gained more recognition as a result of being regarded as a standard for development of internet whilst OSI mode is deemed as a guidance tool.
e. Transport layer of OSI model handles error whilst error is handled at the Internet layer of the TCP/IP model by ICMP.
f. TCP/IP combines the OSI data link and physical layer into one layer, known as the network access layer [1],

3.3 TCP/IP and OSI Models and their suitability for describing global communication:

Software communication is very complicated. International community have come out with protocol suites like TCP/IP and OSI models which consist of layers. These layers make it easy to group related functions together and implement communications software in a much modular manner. Communication from one end of the globe to another goes through these set of protocols structured in layers. TCP/IP has four layers namely: Application, Transport, Network and Data link. The OSI on the other hand has seven layers namely: Application, Presentation, Session, Transport, Network, Data link and Physical. There is overlap of functions between the two models [12].

3.3.1 Application Layer:

At the Application layer, computers are addressed by their host names, since this layer is a user interface area it is easy for human comprehension.eg. Seth-Ghana. In a wider spectrum like Internet, two computers could have the same name. To avoid this, a domain system is used. These domains have subdomains. The domain name for a host located at Ellen Company could be described as Seth-Ghana@Ellen.com. The hostnames are used to communicate with a host in another Internet site. When it comes to packet formation, these hostnames could not be used to address packets, so they are converted to IP addresses which are used to address packets. This conversion is done by a centralised host file called Domain Name Service (DNS) server. This Application layer action at TCP/IP covers three layers' action in OSI model namely Application, Presentation and Session [12].

3.3.2 Transport Layer:

The layer is also known as host-to-host layer; the functions are like that of transport layer of the OSI model. The layer addressing consists of destination and source port number. Each protocol at the Application layer determines port numbers and also the transport layer protocol to use, that is either TCP or UDP.TCP is executed in hosts. The TCP at each corresponding host ensures that data is delivered in precise, sequential, complete and free from duplication. UDP does not secure delivery of packets. It is the responsibility of peer applications to exchange information which confirms that data has arrived safely [12].

3.3.4 Internet Layer:

The internet layer is analogous to network layer in OSI model. Software address is used by all hosts. The IP address consists of octets or 4 bytes that is made up of both network and host address. Each computer's network address must match with the network address of other computers within the network, on the other hand the host address must be unique. A computer on the Internet uses this network address. An example of an IP address is 192.168.1.3. The number is assigned by Internet service providers. The IP protocol support three classes of addressing system: A, B, C. The value of the first octet make out the class to which an address belongs to. Class A has 1- 126, Class B has 128 – 191, Class C has 192 – 233.In class A, the first byte is for the network address and the remaining 3 bytes are for the host within the network. In class B, the first two bytes are for the network address and remaining two bytes for the host within the network. In class C, the first three bytes are for the network address whilst the last part is for the host within the network [12].

The Table 3.1 below shows classes and their network numbers:

Table 3.1 Network Classes and their Numbers:

Class A

Network 1- 126	Host	Host	Host

Class B

Network 128- 191	Network	Host	Host

Class C

Network 191- 233	Network	Network	Host

A routing table is maintained which supplies various information like ultimate destination network number, a metric, the next router's IP address in sequence to get to the destination. The lower the metric, the better the route. Routing protocols like RIP, IGRP are used. Some manual routing could be done, by specifying a destination and gateway address for host, this method is called a static routing.

3.3.5 Network Access layer:

This layer is essentially a combination of physical and data link layers of OSI.The function of this layer is to issue packets across the physical link from one device to another and make use of MAC addresses to deliver packets on a network segment. MAC address is a set of 6 byte of information, usually represented with hexadecimal numbers.

Example is 08:CA:00:12:34:56. MAC address is unique, the first 3 bytes are ssigned by a centralised body to the manufacturer. MAC address is used to deliver packets locally within a network. During transfer of packets whiles the IP source and destination address remain constant, the MAC address keep on changing each time it passes through a router. According to [25], other properties like, voltage levels, timing of voltage changes, physical data rate etc. allow data to be sent and received accurately.

3.4 Encoding Schemes:

Encoding scheme is a means of modifying the actual bit stream to transmit over a cable by encoding the clock and synchronous bit stream. This action takes place at the physical layer of the OSI model. The advantage of encoding is to ensure that bit stream received are unambiguous and the receiver is able to determine the start, end or middle of each bit without reference to external clock. There are two different approaches to this encoding scheme, they are Manchester encoding and Differential Manchester encoding. With Manchester encoding, each bit period is divided into two equal intervals. A binary 1 bit is sent by setting the voltage high during the first interval and low in the second interval. A binary 0 is just the reverse. The Manchester encoding scheme ensures that every bit period has a transition in the middle. Manchester encoding scheme's disadvantage is that it requires more bandwidth because the pulse is half the width. Differential Manchester encoding on the other hand uses 1 bit to indicate the absence of a transition at the start of the interval. A 0 bit to indicate the presence of a transition at the start of the interval. There is a transition in the middle as well. The Differential Manchester encoding scheme offers better noise immunity, but requires complex equipment [12].

3.5 Bandwidth:

According to [12], the Bandwidth of a device is the amount of data that it can transmit in a fixed amount of time. Data rate is the rate at which bits are transmitted in a device. Information can be transferred in a medium by varying some physical properties such as voltage or current. The capacity of Bandwidth determines the magnitude of the data rate [12]. Limiting the Bandwidth limits the data rate.

Nyquist proved this with his theorem which states that:
Maximum data rate = $2H \log_2 V$bits/sec.
H = Bandwidth.
V = discrete signal levels.

3.6 Signal formats:

The signalling method employ by Local Area Network at physical layer level of the OSI model refers to both the way data is encoded for transmission and the frequency spectrum of the media. Two signalling methods used are broadband and baseband signalling. In broadband signalling, the transmission media bandwidth is subdivided into subchannels with each subchannel allowing data transfer independently. Baseband signalling allows only one signal transmission on the medium at any point in time. Broadband signal method is more complex than Baseband signalling method. It requires information to be transmitted through the modulation of a carrier signal. Baseband is use to transmit data since it uses one channel. Broadband on the other hand is use to transmit voice, fax, video since it has several sub channels. The signalling nature of Broadband is analogue whilst that of Baseband is digital. Baseband uses a technique called Manchester or Differential Manchester Encoding scheme to transmit signals [12].

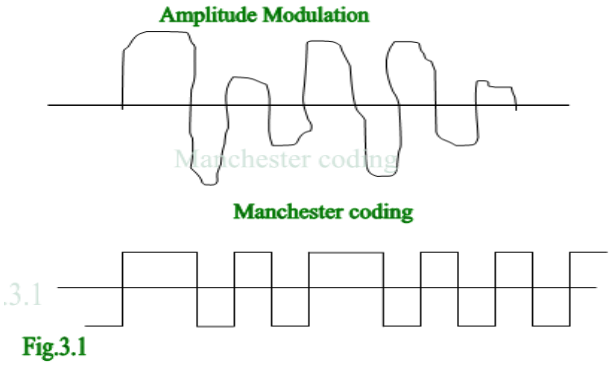

Fig 3.1 above depicts the Broadband signal waveform with amplitude modulation and Baseband signal waveform with Manchester coding waveform.

4. Different Media Types Used in the Campus Network

The University network system has 13 routers installed at separate location in the campus and connected together in a star topology to provide effective service.71 switches are installed in various buildings. 10/100MPS fast Ethernet are connected to desktops and laptops through category 5 UTP cabling. 9 wireless access points have been created to augment these services. Below is a block diagram of the KTU campus network.

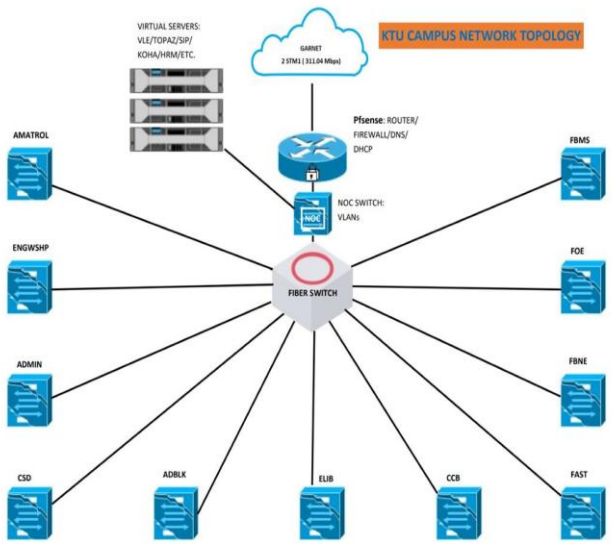

Figure 4.1: KTU Campus Network

4.1 Unshielded Twisted Pair category 5.

The Unshielded Twisted Pair (UTP) has four pairs of wires, two of the wires are wrapped round each other forming two pairs of twisted wires. The theory behind this is that the wrapped wires around each other conduct noise and there are other external interferences, the purpose of the winding is to cancel out electromagnetic interference from external source and crosstalk from neighbouring wires. The set up cost is low, very easy to set up and require minimum tool kits to set

up. The twisted- pair wire supports Bus, Star or Star topology.

4.2 Implementation problems
The data rate reduces as the signal travels over the twisted pair. Example is at 100 meters the twisted pair can carry about 100mbps but this will reduce to 2mbps at 5.5km. Repeaters are required at short distance to regenerate signal at certain distance thus adding to the implementation cost.

4.2.1 Bandwidth/data rate

The UTP has a data rate of 100MBPS.

According to [22]. H. Nyquist in 1924 realised the existence Bandwidth – limited signal and derived an equation expressing the maximum data rate for a finite bandwidth noiseless channel. Claude Shannon in 1948 extended Nyquist's work to a channel subject to random noise. Nyquist proved that an arbitrary signal passing through a low-pass filter of bandwidth H, the filtered signal can reconstruct by making only 2H sample per second. He further stated that if the signal consists of V discrete levels, then:

Maximum data rate = $2H \log_2 V$bits/sec.

From the above theorem, there is a direct relationship between the Bandwidth and Data rate. That is increasing bandwidth increases the data rate.

4.2.2 Security
Twisted-pair is highly vulnerable to interference and distortion, including electromagnetic interference (EMI), radio frequency interference (RFI), and the effects of moisture and corrosion. It is also easy for an individual to simply pull out the twisted-pair terminating on a modular plug and replace it in another jack in the enterprise, without requiring the intervention of a technician.

4.2.3 Signal format:
The twisted- pair wire system is used to transmit both voice and data, the data transmission is baseband and therefore only one channel is used for that. Manchester or differential Manchester encoding scheme is technique use for baseband signalling. It prevents direct current (DC) voltage build up, thus enabling repeaters to be spaced father apart from one another.

4.3 Fibre optic cable
Fibre optical cable is a solution to electromagnetic interferences in data transmission. Fibre optic cable convert data represented by electrical energy into light energy. This is done by the use of light – emitting diode at the receiving end of the cable and converts it back to electrical energy at the sending end by a device known as photo detector. Since data travel in the form of light in fibre optic cable, it is immune to electrical interference and to the building codes that often require expensive conduit for conventional cables. Another common use of fibre optic cable occurs in constructing Fibre Distributed Data Interface (FDDI) network. Fibre Distributed Data Interface (FDDI) network is used primary as a backbone during highway connecting two or more Local Area Network [6].

4.3.1 Implementation problems
The use of fibre, calls for specialized test equipment because none of the test equipment you use on an electrical network will work with fibre. You need an OTDR, and when you get into more sophisticated optical networks, you need highly specialized optical probes that can be quite costly, and you need one at each location.

Most fibres provide only a single unidirectional transmission path, but a minimum of two cables is required to connect all transmitters to all receivers on the network.

It costs more per foot for fibre cable than UTP and also require some specialised knowledge to install fibre optic cable. Fibre is a small medium, so it can very easily be cut or otherwise damaged during construction activities.

Bandwidth/data rate

The fibre optic has a bandwidth of 75THz.

4.3.2 Security
Fibre do not leak light and are quite difficult to tap, this give them excellent security against potential wire tapper. Fibre optic cable is also useful in hazardous environments because it can not spark, it does not contain any metal hence resist corrosion.

A number of flora and fauna cause damage to fibre. Some birds really like the Kevlar reinforcing material and think it makes lovely nests for their babies, so they peck away at fibre optic cables to get at that Kevlar material. Rodents such as beavers like to sharpen their teeth on exposed cable. Several different types of ants seem to enjoy the plastic shielding in their diet, so they nibble at the underground fibres [24].

4.3.3 Signal format:
The ray that passes through the fibre cable is called a mode, it enters at a particular angle. A single mode fibre sends transmission along a single path. This beam of light is very intense, so single mode fibre can carry more data for longer distance and it is suitable traffic intensive application. Multimode fibre allows multiple modes to pass through the cable at once. The mode bounce inside the cable in a zigzag, the ray then moves like a sine wave. Multimode fibre optic cable is prone to modal depression [13].

4.4 Wireless Access point
Wireless networking operates in a similar principle to cabling networking. Essentially it is a method of connecting devices without having cabling running between them. It is normally use when wiring is not possible or for client who join and leave networking frequently or do not have access to a desk with network connection. Wireless LAN utilises radio waves as their transmission medium and so the rules governing propagation of radio waves is applicable to its use. Unlike cabling access point wireless access point could be moved from one location to another depending on clear line of sight between the client and access point [21].

4.4.1 Implementation problems

The access point must be in an open environment to have a better coverage than a closed or relatively closed environment. Performance is affected by an obstruction between the client and access point. The building material is another factor which influences the range of signal, dry walls allow radio waves to penetrate better than metal or bricks wall. In multiple access point installation, too much or too little overlap can cause disruption of wireless connection to the client. Too little overlap causes the client to loose coverage when roaming between access points. Too much overlap result in interferences of access points. There are issues of pry of information in transits and misuse of access points by unintended user which must be dealt with. Requirement for regulatory licensing means enough time is needed to deal with spectrum Agency before installation commence [26].

4.4.2 Bandwidth/data rate

The bandwidth is 100GHz.

The property of radio wave is frequency dependant. At low frequencies, radio waves pass through obstacles well, but the power reduces with distance from the source.

4.4.3 Security

Any object which obstructs the signal transmission poses as threat to the performance of the access point. The radio waves are absorbed by rain. The frequencies of radio waves are subjected to interference from motors and other electrical equipment.

5. Critical analysis of Koforidua Technical University network and solution in terms of different media to optimise the network.

The school's network is a mix topology. At the department level, computers are connected to switches in a form of star topology. These switches from different departments are connected to routers in a form of star topology. This means that a problem with a computer within a department will not affect other computers in the department. A problem with the network controller like a switch within the department will render the whole department network system inoperative. At the star topology level, the problem with any of the routers transmission media in the star will render the whole school's network system inoperative. The speed of the channels use by the school's network is slow (Unshielded Twisted Pair category 5).This has a potential of causing congestion as the student population grows. The wireless access points of the University must be secured and upgraded to avoid intruders.

5.1 Solution

The study recommends to the school to use Fibre Distributed Data Interface (FDDI) network. FDDI uses a star topology with two counter rotating stars for reliability. The cable type is fibre optic. Though it is expensive, it has a lot of advantages over existing cables. The media access method is token star. FDDI is normally used as a backbone to link other networks. The Wireless Access Points must be upgraded to a Gigabit grade to them scalable enough to provide high availability and low latency.

6. Conclusion

By comparing the OSI and the TCP/IP Reference Models, the study found out that even though the OSI Reference Model has seven layers, it is possible for TCP/IP to produce all the needed protocols with its four layers and also some of the layers merging the functions of two or more layers in OSI model. Manchester and Differential Manchester encoding schemes were identified as an efficient technique employed to transmit signals through cables. Finally, the school's network was looked at and it was recommended that FDDI network is introduced to ensure optimum use of the network.

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